Productivity and Labor Costs in the Ontario Metal Mining Industry

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NOTE:

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INTRODUCTION

This study emerged from a sample survey covering labour costs in the Ontario metal mining industry which formed part of the volume entitled Ontario Metal Mining Statistics. The survey provided a rich body of micro data on direct and indirect labour costs for fifteen firms covering a broad spectrum of Ontario mining companies.

Initial work with these data for the volume revealed that a major shift had taken place in the structure of compensation payments in this sector. Briefly, over the last two decades the share of indirect to direct labour costs had risen sharply. It seemed imperative that the implications of this structural change be recognized, and studied, in connection with the observed performance of the mining sector over this period of wage transition; i.e., from 1960 to 1977. In particular, investigation was undertaken on the link between wages (and wage structure), commodity prices and productivity.

The work was commissioned by the Metallic Minerals Section, Mineral Resource Branch of the Ministry of Natural Resources to become part of its series on Mineral Policy Studies. We wish to thank the many representatives of the Ministry and the industry for their assistance and support in this work.

CHAPTER I

A REVIEW OF THE THEORY OF PRODUCTION AND RECENT EMPIRICAL RESULTS USING A COST FUNCTION APPROACH

The central focus of this study is on the demand for labour in metal mining with particular reference to the Ontario mining industry. Since labour is only one of the inputs to the mining production process -- albeit, as we shall show, an important one -- we need to review the general nature of productivity growth and cost changes over the recent past in order to get some perspective on how demand for labour has been influenced by its price and the price of other inputs.

This chapter is divided into two sections. The first part will set out briefly the theory of production which underlies the analysis of productivity change and discusses types of measurement errors, especially in relation to labour inputs, that might distort the results from such an exercise. The second part will review two studies which used a cost function approach to the study of factor substitution and technological change in the Canadian mining sector. The focus will be on the demand for labour as revealed in these two studies and the elasticity of substitution between capital and labour. The degree of substitutability, as we will show, is important in trying to explain behavior in the industry when it is faced with increased labour costs.

In Chapter II net output production functions are reviewed, including results of a study of productivity change in the Ontario metal mining industry.

I. THEORY OF PRODUCTION

The basic theory of production is very straightforward. Quantities enter the production as real output and real factor inputs. The latter are weighted according to their relative contribution to the total cost of production. In this type of exercise the usual equilibrium conditions hold between the price of a factor's services and its marginal contribution to output. There is also a presumption that commodity or producers markets are in equilibrium; i.e., price = marginal cost = average cost. Finally, marginal rates of factor substitution are identified with the corresponding factor price ratios.

Although the concept of production theory is quite straightforward, the execution of the function to obtain total factor productivity is not always simple. Total factor productivity measures the shift in the production function; i.e., movements of the function towards the origin. If the inward shift occurs along the same vector or ray from the origin then the technological change which gives rise to this shift is said to be Hicks or Harrod neutral; i.e., the production isoquants do not change their shape. In other words technical change is neither labour saving nor capital using.

To estimate Total Factor Productivity (i.e., T.F.P.), then, requires a specific set of information -- real output, real capital stock, labour in man years or man hours, energy and materials purchased from other sectors which are used to transform the "raw material" into final output. The data requirements in such an exercise are really quite rigorous, especially the requirement for estimates of real capital stock and its counterpart the capital service price.

It has become common, recently, to circumvent, partially, these measurement problems by estimating a cost function. To demonstrate this point we will adopt the following notation:[1]

Y_i = quantity of i^{th} output

X_j = quantity of j^{th} input

q_i = price of the i^{th} output

p_j = price of the j^{th} input.

If we assume m outputs and n inputs and a fundamental accounting identity, then

$$q_1Y_1 + q_2Y_2 + \dots q_mY_m = p_1X_1 + p_2X_2 + \dots p_nX_n \qquad (1)$$

Total differential with respect to time gives

$$\Sigma\, w_i \left(\frac{\dot{q}_1}{q_1} + \frac{\dot{Y}_i}{Y_i}\right) = \Sigma\, v_j \left(\frac{\dot{p}_j}{p_j} + \frac{\dot{X}_j}{X_j}\right) \qquad (2)$$

where w_i and v_j are the weights of output and inputs. The weights are

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[1] This section of the chapter draws heavily on the pioneering article by Jorgenson and Griliches, "The Explanation of Productivity Change", Review of Economics and Statistics, 1967.

defined as the relative shares of various outputs and inputs in value terms. This is referred to as a divisia quantity or price index.

The rate of growth of total factor productivity (=TFP) is

$$\text{Output T.F.P.} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} = \Sigma\, w_i \frac{\dot{Y}_i}{Y_i} - \Sigma\, v_j \frac{\dot{X}_j}{X_j} \qquad (3)$$

$$\text{Cost T.F.P.} = \frac{\dot{p}}{p} - \frac{\dot{q}}{q} = \Sigma\, v_j \frac{\dot{p}_j}{p_j} - \Sigma\, w_i \frac{\dot{q}_i}{q_i} \qquad (4)$$

As we see in equation (2) the cost relationship is just the other side of the coin to the output estimate; i.e., the dual of the latter.

The most frequently used cost equation is the translog function. The results from estimating this function are shown in the remaining segments of this chapter. Although an estimate of T.F.P.; i.e., here minimizing the cost per unit of output, can be calculated from the translog production function. Our interest will focus more on the nature of the demand for labour (own and cross price elasticity of demand) and the degree of elasticity of factor substitution. If, then, we assume factor prices and output are exogenous and that firms are cost minimizers,[2] then the cost function takes the following form:

$$c_i = q_i\,(p_{Ki},\ p_{Li},\ p_{Ei},\ p_{Mi},\ q_i,\ t)$$

where c_i is the total cost of the i^{th} industry and p_{Ki}, p_{Li}, p_{Ei}, and p_{Mi} are the prices of capital, labour, energy and materials inputs for the i^{th}

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[2] The assumption that firms are always cost minimizers may not hold in periods of heavy demand when producers face sharp increases in corporate taxes and individuals incur higher personal taxes.

industry respectively. Output level is captured in q_i and technological change in t. The results reported in the balance of the chapter take the usual translog functional form.

II. COST FUNCTION APPROACH: TWO RECENT STUDIES

One of the pioneer studies into productivity and technological change in the Canadian metal mining industry was the one done for the Ontario Ministry of Natural Resources.[3] As the title infers this study set out to investigate how changes in relative factor prices influence the nature of technical change in the Canadian mining industry. In other words how much manoeuvering room do mining operators have between capital, labour and energy inputs in the face of rising relative prices for any one of these factor inputs? Can producers really cut back on the use of labour inputs in the face of steeply rising relative prices of this factor?

If we concentrate mainly on the response of labour demand to its own relative price changes and those of capital and energy and furthermore focus on results for metal mining -- the concern of this study -- some interesting results from the Smithson, et. al. Study are revealed. First, one should recall that the authors of the latter estimated the

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[3] C.W. Smithson, G. Anders, W.P. Gramm, and S.C. Maurice, Factor Substitution and Biased Technical Change in the Canadian Mining Industry, Mineral Policy Background Paper No. 6, (Ontario, Ministry of Natural Resources, 1979).

substitution parameters via a set of generalized cost functions, unlike this study which focuses on real outputs and inputs, and that the Smithson, et. al. Study covers the period 1950-74; i.e., the years before the "energy crises" hit the Canadian economy.

Briefly the findings, using the complete four input model; i.e., capital, labour, energy and raw ore, for the Canadian metal mining industry (the authors also applied their model to the non-metal mining industry), are as follows:

(1) Capital and labour are relative complements.

(2) Significant substitutability exists between capital and energy.

(3) Labour and energy are complementary inputs.

(4) Complementarity exists between raw ore and all other inputs.

(5) Technical change in metal mining has been capital-using, labour-saving, and neutral with respect to both energy and raw ore.[4]

According to the authors the trend movement of the four factors indicates that, for the period 1950 to 1974, the price of capital services relative to labour and energy was stable. However the price of labour (and ore), rose relative to that of energy. It is difficult to interpret what the authors meant by "stable". How these input prices actually

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[4] Smithson, et. al., op. cit., pp. 103-104.

moved is important for us in interpreting the results of the cost function's empirical findings. Using the authors' input price figures[5] the growth of the four factor prices over the period 1950 to 1974 is as shown in Table I-1.

The calculations of annual rates of change of capital, labour, energy and ore prices reveal a most interesting pattern. If we look first at line 7 which covers the whole period of their study (i.e., 1950 to 1974), it shows that the two fastest growing prices are those of labour and the raw material input, ore. Of the two the price of ore appears to be the most volatile. Recall that the authors calculated the price as the tax rate per ton for Ontario multiplied by the total number of tons of ore hoisted in Canada in a given year.[6] Given the method used to calculate this price it is difficult to explain this annual variation. It might well be that, since, as the authors state, the Ontario mining tax is a profits tax then the volatility is more a reflection of variation in mining profitability than of the simple price of the natural resource input, although in a general sense these two are probably related.

The price of labour is another story. Although it rises at an annual rate of 10.7% this increase is much smoother over the period, accelerating somewhat in the late sixties and early seventies. The increase in the price of labour shown in Table I-1, it should be noted,

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[5] Smithson, _et_. _al_., _op_. _cit_., Table 2, p.17.

[6] Smithson, _et_. _al_., _op_. _cit_., p. 109.

TABLE I-1

Annual Rates of Growth of Factor Prices for Selected Periods, 1950-1974, for the Canadian Metal Mining Industry

		Annual Percentage Growth			
		Capital (1)	Labour (2)	Energy (3)	Ore (4)
(1)	1950-54	.025	6.166	2.684	-0.142
(2)	1955-58	.734	5.416	1.719	4.162
(3)	1959-62	-.704	2.981	3.071	18.266
(4)	1963-66	4.178	4.416	-2.243	25.509
(5)	1967-70	-.957	8.698	.544	8.907
(6)	1971-74	2.761	9.019	3.684	59.561
(7)	1950-74	1.70	10.67	2.680	21.49

Method: (1) The formula used to calculate annual growth rates is as follows:

$$AGR = \left[\frac{(X_t)}{(X_i)}^{1/n} - 1 \right] \cdot 100$$

where X_t = terminal year value

X_i = initial year value

n = years in period.

Source: Smithson, et. al., op. cit., p. 17.

does not include indirect labour costs; e.g., the cost of holiday pay, sickness benefits, pensions, etc. The latter, were estimated by the authors to have risen from 10% of the direct wage and salary bill in 1950 to 50% by the mid seventies. To verify these estimates was one of the original motives for undertaking the labour cost survey. One of the purposes of this study then is to focus on how these two "costs", direct and indirect, have influenced developments in the industry. In the past labour (to the industry) and (direct) wages paid to the worker have been treated as identical. It is of the utmost importance to take account in any analysis of the implications of this increasing gap between labour cost and labour price which has arisen over the last two decades.

The other two inputs -- capital and energy (Cols. (1) and (3), Table I-1), show remarkably small annual increases over the study period. The annual increase in the service price of capital appears to have been less than the increase in the general wholesale price index over this period. Indeed in certain periods; i.e., 1958-62 and 1966-70 the price actually falls. The price of energy (here measured exclusively as the price of electricity per KHW) is similar in its increase, with the biggest jump occurring in the early seventies.

Since the share of capital and labour in total cost for the metal mining industry is close to 90%,[7] it would seem that relative price performance of these two inputs is critical to our understanding of

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[7] Smithson, et. al, op. cit., p. 35.

developments in this sector. Table I-2 sets out the average ratio of the price of capital to the price of labour for selected years from 1950 to 1974.

The most startling conclusion from this exercise is the sharp drop in the price of capital relative to the price of labour over the study period. This relative decline was not evenly distributed over this decade and a half. From the early fifties to the mid sixties the relative price was fairly stable. The major shift did not begin until the late sixties and then accelerated in the early seventies. To repeat an earlier observation this relative price change when direct and indirect labour costs are included must have been even larger than that shown in Table I-2. We must keep the timing of this change in mind when the impact of labour costs on metal mining developments is reviewed in later parts of the study.

Factor Demand

The demand for any factor of production is a derived demand and hence is related to the nature of the market for the final product. Since the metal mining industry sells much of its products on a world market one might expect that this sector faces a fairly elastic demand for its products -- i.e., small percentage increases in price (relative to the world price) would substantially reduce demand and vice versa for a drop in price relative to other world supplies.

TABLE I-2

Price of Capital Relative to the Price of Labour, Selected Periods, 1950 to 1974

	P_K/P_L [1]
1950-56	.029
1957-65	.021
1966-70	.015
1971-74	.008

Source: Smithson, *et. al.*, *op. cit.*, p. 17.

Note: 1. P_K = service price of capital
P_L = price (direct wages) of labour.

It is important for our later discussion to review what the shape of the demand curve for labour looks like since in all markets (commodity or factor) the observed price is the result of the interplay of supply and demand forces and the slope (elasticity) of the respective functions. In this section we will review the Smithson, et. al. results and in subsequent sections other results.

In Smithson, et. al., the authors use a four and a three input production function for the Canadian metal mining industry. Here we will confine our review to the three input case since this is the common approach used in more recent studies. The three inputs are labour, capital and energy. In the Smithson, et. al. study, due to data constraint problems, the period for which the trans log cost function was tested covers the twelve years from 1962 to 1974. This constrained period makes a direct comparison with other work less precise than one would like; i.e., starting later in the postwar experience and terminating earlier. Nevertheless one would not expect the parameters to be widely different, at least theoretically, since the studies reviewed here encompass the main period of most rapid technological change in metal mining since the end of the Second World War.

Table I-3 sets out the Smithson et. al. results on own and cross price elasticities of demand for the three inputs -- capital, labour and energy. Own price elasticity of demand is defined as the change in quantity demanded of a given factor input with a change in its price, holding the price of all other factor inputs constant -- the usual demand

TABLE I-3

Estimated Elasticities for the Three-Input Production Function, Canadian Metal Mining, 1962-1974
(Asymptotic Standard Errors in Parentheses)

A. Own-Price Elasticity	
Labour	-0.475*
	(0.123)
Capital	-1.178*
	(0.320)
Energy	-27.817*
	(9.201)
B. Cross Elasticities	
Capital on Labour	0.565*
	(0.166)
Capital on Energy	1.676*
	(0.555)
Labour on Energy	1.476
	(0.914)

*Significantly different from zero at a 95% confidence level.

Source: Smithson, *et. al.*, *op. cit.*, p. 121.

curve relationship. Cross-price elasticity of demand is the responsiveness of demand, for a given factor, say capital, to changes in the price of another factor, say energy. For example, over the last decade energy prices have risen rapidly and the question has been raised as to whether industry would increase its use of capital (assumed not to have gone up in price as much as energy) relative to its use of energy. The assumption is that the demand for energy would decline. Hence we are interested, in measuring cross elasticities of demand, in the example given, of the effect on the amount of capital demand which results from a change in the price of energy. If, indeed, the effect is positive then capital and energy can be said to be substitutes. If the relationship is negative or zero then the factors can be said to be complements; i.e., as less energy is demanded due to its rise in price so also is less capital used. One can think of cases where the increase in fuel prices has caused a reduction in capital usage; i.e., the two are complements.

The econometric results for own price elasticity of demand as shown in Table I-3 are quite surprising. They suggest that the price elasticity of demand for capital and especially energy is extremely high -- and this was the period before the jump in energy prices; i.e., up to 1974. The parameters indicate that for a 10% increase in the price of labour the quantity demanded would drop 4.8% while for a 10% rise in the price of the other two factors we would witness a drop in demand of 11.8% and 278.2% respectively. If we can take that the elasticity of factor demand is a measure of factor productivity; i.e., with output fixed, a rise in price decreases the quantity demanded and hence an increase in

this particular factor's efficiency, then the capital and especially the energy productivity response rate is really quite high.

Before these results are accepted at face value a caveat is necessary -- one with which we are certain the authors would agree. The size of the parameters recorded in Table I-3 is not unrelated to the behavior of the underlying price series from which they are derived. Hence we would expect a more volatile price series to yield larger coefficients. As we saw in Table I-1, capital and energy prices vary much more than did the price of labour. Hence part of the differential elasticities is simply a reflection of this greater variability.

If, then, we allow for the differential underlying price variability between the three input series, the finding that price elasticity of demand for labour is lower than for capital or energy is important for our study. It is important since the results imply that the quantity of labour demanded would fall much less than theory -- the derived demand for factors being a reflection of the nature of demand for the final product -- had initially predicted. This implies, but does not prove, that there are few close substitutes for labour in the mines but that for capital and energy substitutes do exist; i.e., if the price of capital rises the mine owners can substitute labour or energy. This is even more the case for energy where these results imply the potential existence of a wide range of substitutes.

Panel B of Table I-3 reinforces this suspicion. In all three cases shown the parameter is positive indicating the existence of substitutability between the pairs of factors shown. The important finding is that capital and energy are substitutes but that labour and energy appear to be complements; i.e., the coefficient for the latter pair although exhibiting a positive sign is not statistically significant and so the coefficient can not be assumed to be different from zero. These cross elasticity findings tend to reinforce the own price conclusions that labour has few substitutes in the metal mining industry, at least in the near term.

Stollery

The other major study which adapts a translog cost function approach is that done by K. Stollery for the Economic Council of Canada.[1] There are two major differences in the structure of the Stollery study over that of Smithson, et. al. First Stollery incorporates the influence of changing ore grades directly into the cost function. The whole concept of ore grade, its measurement and its effects on mining activity is a difficult one to deal with in this type of analysis. Differences between geological and economic ore grades must be kept in mind since the way we measure each is very different and differences in ore grade changes in a small mine versus general ore grade levels in an industry are important to distinguish clearly in any analysis. Ore grade,

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1 K.R. Stollery, Productivity Trends and Their Causes in the Canadian Mining Industry, 1957-79, Discussion Paper No. 248, Economic Council of Canada, Dec. 1983. Hereafter Stollery (1983).

for example, in a small mine may decline as development progresses but this need not be the case in a large mine or in a region where new grades are brought on stream as older and lower grades are retired leaving the average grade mined relatively constant.[9] Smithson, et. al., made no adjustment for changing ore grade. Second Stollery, following the earlier work of Dawson,[10] breaks the mining sector into its main constituent industries; i.e., asbestos, copper, nickel, gold, iron and silver, as well as into the broader industry classifications of metals, nonmetals and total mining activity. The period of coverage is from 1957 to 1979 and the focus is on the Canadian mining industry as in the Smithson, et. al. study. Regional (provincial) differences are not covered in either study.

Briefly the main conclusions of the Stollery study are as follows:

(1) There is clear evidence of a trend decline in multifactor productivity which apparently began before the seventies.

(2) Throughout the period there was a substitution of capital and energy for labour. This substitution sharply increased labour's productivity relative to that of the other two factors.

(3) Capital and labour were shown to be weak substitutes.

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[9] For a further discussion on the potential impact of ore grade on productivity measurement see, "The Mineral Industry and Canadian Economic Growth". A statement prepared by the Mining Association of Canada delivered at the 41st Annual Conference of Provincial and Territorial Ministers of Mines and Resources, Yellowknife, N.W.T., August 8, 1984, pp. 7 and 8.

[10] John Dawson, Productivity Change in Canadian Mining Industries, Staff Study No. 30, Economic Council of Canada (Ottawa, 1971).

(4) Technological change was found to be capital and energy-using and labour-saving.

(5) Declining yields have had a significant negative effect on productivity for some of the industries studied.

(6) In general output growth was found to be non-homothetic - rather it was labour using and capital saving.

Although there were other conclusions these seem to be the ones most important for our study. In this connection one or two points of difference between the Stollery results (for metal mining) and those found by Smithson, et. al., should be noted. First, Stollery's statement that "in general" output growth was non-homothetic does not seem to apply to metal mining where the coefficients on the relevant parameters (i.e., y_{QL} and y_{QK}) are in fact signed in a manner consistent with this conclusion but are not statistically significant. Smithson, et. al. find the production function for metal mining to be homothetic. Second, Smithson, et. al., found that there appears to be significant substitutability between capital and labour whereas Stollery found these two factors to be weak substitutes. We are therefore left in a quandary as to what effect a rise in labour's price (cost?) might have on the degree of factor substitution, especially between these two key inputs, capital and labour. Finally one would like to know why, for Stollery, the own price elasticity of demand for energy is statistically insignificant while for Smithson, et. al, it is large (i.e., very elastic, so assuming that a rise in energy price causes a large drop in the quantity of energy consumed), and statistically significant. Much of the metal mining industry's

response to the 1974 OPEC crisis hangs on this response rate. Surprisingly the smaller coefficient (Stollery's) includes the post 1974 years whereas Smithson, et. al., conclude their study period in this year. One must wonder whether the way energy costs are measured is an important explanation for these different results; i.e., Smithson, et. al, only include electricity as the cost of energy while Stollery takes total energy costs, including fuel oil, gas, etc., into account. This whole area of energy cost and productivity apparently needs further work.

The other difference between the two studies, and one which leads to very important implications on industry performance over this period, is the trend in relative factor prices. Table I-4 sets out the trend-ratio in the price of capital relative to the average price of labour for selected periods from 1957 to 1979.

The startling conclusion from this exercise is that the price of capital rises relative to the price of labour over the whole period, although there is some evidence of a reversal in this trend after 1970. This result is in direct conflict with the finding of Smithson and his colleagues who showed the price of labour rising relative to the price of capital, especially from 1971 to 1974.

One must wonder then how Stollery obtained his results that the mining industry biased its technical change towards capital and away from labour. He states that the high incidence of strikes in the industry may have accounted for this apparent anomaly; i.e., the industry conserving

TABLE I-4

Price of Capital Relative to the Price of Labour, for Metal Mining, Selected Periods, 1957 to 1979

	P_K/P_L
1957-65	100.0
1966-70	123.9
1971-79	117.6

Source: K. Stollery, *op. cit.*, p. 34.

on the use of the relatively cheaper factor, labour. But here again, Stollery's statistical test on the influence of strikes in this sector shows "no strong econometric evidence to support the contention that the deplorable record of labour relations in Canadian mining has materially reduced the rate of measured productivity" (p. 71).

To investigate this trend in relative factor prices further, Table I-5 was constructed. This table sets out the trends in the share of labour, capital and energy costs in total costs as derived by Smithson, et. al. and Stollery. Although the periodization of the two studies is not exact, nevertheless there is enough overlap to allow for a good comparison of share trends. The interesting finding is that the time trend for labour's share falls while capital's share rises and energy's share is relatively unchanging. In terms of the latter, we see what a small percentage of total cost goes to pay for this input. The key shares are capital and labour, with labour's share larger than that of capital at the beginning of the period but falling steadily. With low substitutability between capital and labour, recorded in both studies, the rise in capital's share is consistent with an increase in the capital-labour ratio which one would expect when labour's price rises relative to that of capital. The trend in factor shares found by Smithson, et. al., is consistent with these underlying price trends.

The Stollery findings are more difficult to interpret since he found low substitutability between capital and labour, and a rising capital-labour ratio yet, to repeat, capital prices rising faster than the

TABLE I-5

A Comparison of Labour, Capital and Energy's Factor Shares Between Smithson et.al. and Stollery, Selected Periods, 1957-1979

	Smithson,et.al.			Stollery		
	S_K (1)	S_L (2)	S_E[1] (3)	S_K (4)	S_E (5)	S_K (6)
1957-65	.300	.650	.050	.327	.601	.072
1966-70	.360	.587	.054	.439	.488	.073
1971-74	.393	.555	.051	-	-	-
1971-79	-	-	-	.518	.403	.078

Cols. (1)-(3) Smithson, et. al., op. cit., p. 29.
Cols. (4)-(6) Stollery, op. cit., p. 34.

Note: 1. S_K, S_L, and S_E are respectively the factor shares of capital, labour and energy.

cost of labour. There is obviously something here that needs to be studied. One suspects that such a study should begin with a look at factor price trends. This report begins such a review of focussing on the price (cost) of labour to the metal mining industry.

To complete this review it seemed important to compare the own-price elasticity of demand coefficients derived by Stollery with those estimated by Smithson, et. al. Table I-6 sets out these factor demand coefficients.

Although the coefficients are correctly signed (negative), unfortunately for metal mining only labour's coefficient is statistically significant. On the surface this indicates that, holding other prices constant, an increase in the price of capital or energy will not affect the quantity of that factor demanded, in a statistically significant manner. For labour, on the other hand, an increase in the price of labour ceteris paribus, means less labour is demanded; i.e., it is possible to substitute capital or energy for labour. Again this result appears at variance to the Smithson, et. al. study. As reported earlier the chief conclusion from the Smithson et. al. study was that labour was not easily replaced by capital or energy when its price rose. Put another way in the Stollery study we would expect higher increases in labour productivity for a given increase in the price of labour than in the Smithson, et. al. study.

The basic conclusions then that emerge from these two cost function based studies of the metal mining industry are first that capital

TABLE I-6

Input Demand Elasticities for the Metal Mining Industries, 1957 - 1979
(t values in parentheses)

	Own-Price Elasticity
Labour	-.211 (-3.4)
Capital	-.042 (-0.5)
Energy	-.540 (-.70)

Source: K. Stollery, op. cit., p. 43.

labour substitution is probably less than that assumed in a Cobb-Douglas function. In the latter the elasticity of factor substitution is assumed to be <u>one</u>. Second, mining production functions appear to be weakly homothetic and could possibly be homogenous; i.e., a doubling of all inputs results in a doubling of output. Third, the industry exhibits biased technical change; i.e., capital-using and labour-saving.

CHAPTER II

RECENT TRENDS IN PRODUCTIVITY CHANGE

In the pursuit of an understanding of the nature of demand for labour in the mining sector the previous chapter examined the own and cross price elasticity of demand for this factor as well as for capital and energy. The main conclusion was that the demand for labour was fairly elastic while the elasticity of substitution between capital and labour was low.

Besides movements along the demand curve it is essential to examine shifts in the demand curve as well. Shifts in the demand for any factor will depend on the productivity performance of the particular input; i.e., in our case the value of the marginal product of labour. In addition to this partial factor productivity approach there exists, as we outlined at the beginning of the previous chapter, a measure of total factor productivity (T.F.P.). To get some perspective on trends in productivity this chapter reviews the results of some recent studies for the Canadian mining industry and concludes with a look at experience in the Ontario metal mining sector. This review, then, coupled with the results outlined in Chapter I should serve as an introduction to a detailed investigation of labour costs in the metal mining sector in Ontario.

1. Input/Output Approach

In a recent study by the Economic Council of Canada[1] an input-output approach was taken to the study of longer run trends in labour productivity for the Canadian economy and forty sub-sectors. Table II-1 sets out the results of this exercise for total labour productivity over the period 1961 to 1976 for the metal mining sector, and for the aggregate of the 40 industries reviewed in the Postner/Wesa study.

The approach to labour productivity trends used in this study is quite unique. Data from Statistics Canada Input-Output tables is employed to provide a total measure of labour productivity, by industry. Total labour productivity is simply the amount of labour directly required in the final stage of production for a product which is subsequently delivered to final demand. Since, however, a given industry purchases inputs from other industries, then part of the observed labour productivity is due to productivity performance in these supply industries -- known here as the indirect labour component. In this case, then, productivity increases for the indirect labour input must be added to the productivity effects of the direct labour inputs used in producing the final product. The indirect labour input is really a backward linkage to the final product producer.

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[1] H. Postner and L. Wesa, Canadian Productivity Growth: An Alternative (Input-Output) Analysis, Ottawa, 1983.

TABLE II-1

Decomposition of Total Labour Productivity, Average Annual Growth Rate for Metal Mines, and Aggregate Output for 1961-66; 1966-71; 1971-76; and 1973-78

	Total (1)	Own Effects Component (2)	Input Effects (3)
		(A) Metal Mines	
(1) 1961-66	1.7	1.1	0.6
(2) 1966-71	0.6	0.5	0.1
(3) 1971-76	1.3	0.3	0.9
(4) 1973-78	-3.1	-1.9	-1.4
		(B) Aggregate for all Industries	
(5) 1961-66	3.3	1.0	2.1
(6) 1966-71	2.8	1.4	1.5
(7) 1971-76	2.0	0.7	1.3
(8) 1973-78	0.3	0.4	-0.1

Source: H. Postner and Leslie Wesa, Canadian Productivity Growth: An Alternative (Input-Output) Analysis, Economic Council of Canada, Ottawa, 1983.

Lines (1) and (5), p. 20; (2) and (6), p.21;(3) and (7), p. 22; (4) and (8), p. 41.

This measure of direct and indirect labour productivity is different from the traditional measure of productivity. The latter simply divides total output or value added in a specific industry by total labour input. In doing so it does not take account of the inter-industry effects of observed productivity change. The two measures yield almost identical results for industries which are highly vertically integrated; i.e., where intermediate and physical capital replacement inputs are of little importance.

Conversely the two measures; i.e., the I-0 approach and the traditional method can yield quite different levels of output per unit of labour input.[2] This occurs, for example, in metal mining where the industry is highly capital intensive but where the input industries are less capital intensive. This difference in levels of capital intensity, however, need not influence growth trends.

Table II-1, then, records only the I-O labour productivity calculation. Column (1) shows the growth in total labour productivity while column (2) sets out productivity growth which is internal to

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[3] Input-output analysis is a powerful tool for studying the structure of an economy. Basically it is a general equilibrium model which operates under very restrictive assumptions. The model assumes a constant technology, described by fixed coefficients. This represents a very strong non-substitution assumption, i.e. the amount of inputs required for a given level of output is assumed to be independent of either the price of the input or the scale of production. The latter means simply that the model assumes constant returns to scale. Input-output analysis, then, provides a description of the internal operations of an economy and, for what it does, the model has no serious rivals.

metal mining industry. The input effects, (Col. (3)), record the economy-wide impact of productivity change on the metals sector. The "own effect" (Col. 2) is endogenous to the specific industry while the "input-effect" (Col. 3) is exogenous to the industry; i.e., here exogenous to the metal mining industry.

The first conclusion from this exercise is that, for both the metals industry and for the all industry composite there has been a decline in the rate of productivity growth over the study period. This decline has been more pronounced in metal mining than it has for the "all industries group". The major decline for both groups was after 1973 (post OPEC), with metal mining actually recording a negative productivity growth rate.

The input effects; i.e., the impact of technological change in the rest of the economy, have varied in their importance on the rate of total productivity growth for the metal mining industry. By the 1970s these other sectors had become an important component in total labour productivity change. In fact, for the post OPEC period these other sectors were contributing quite strongly to the negative performance of the metal mining industry, much more than for the economy as a whole; see Panel B, line (8), Col. (3).

In another recently published study by the Economic Council of Canada[3] similar trend in productivity performance for the mining sector

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[3] P.S. Rao and R.S. Preston, Inter-Factor Substitution and Total Factor Productivity Growth: Evidence from Canadian Industries, Discussion Paper No. 242, Economic Council of Canada (Ottawa, 1983), p. 31.

(not just metal mining as in the previous study) was found. In this study the authors (Rao and Preston) use a more standard approach to measuring performance trends. The result of these trends, using total value of production adjusted for price changes; i.e., in real terms are shown in Table II-2.

The now familiar pattern on productivity change is revealed again. Before OPEC the mining sector was performing at least as well if not better than the durable goods manufacturing sector. After 1974, although both industry groups exhibit a sharp slowdown in all three indices, it is the mining sector which experiences the sharpest decline. In fact if the mining sector is compared to the other 10 sectors estimated in the Rao-Preston study it turns out to be the poorest performer.

An earlier study on productivity change in metal mining by C. Pye[4] using a total factor productivity approach exhibits similar trends. These are set out in Table II-3.

Although the general trends in partial and total factor productivity are approximately the same in the two studies the actual rates are much lower for metal mining than for the mining sector as a whole. This is understandable since the mining sector includes petroleum production which generally exhibits high productivity levels because it is a very capitalized segment of mining production.

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4 C.H. Pye, Profitability in the Canadian Mineral Industry, Centre for Resource Studies (Kingston, 1981).

TABLE II-2

Trends in Output and Productivity Change in the Mining Industies: 1967-1980

		Output Growth (1)	Output per Man-Hour (2)	T.F.P.[1] (3)
		Panel A - Mining		
(1)	1967-73	7.97	8.55	1.44
(2)	1974-80	0.40	-5.60	-3.48
		Panel B - Durable Manufacturing		
(3)	1967-73	6.44	4.91	1.22
(4)	1974-80	1.57	0.64	0.17

Note 1. T.F.P. = Total Factor Productivity.

Source: P.S. Rao and R.S. Preston, *op. cit*, p. 31.

TABLE II-3

Annual Rates of Growth of Labour and Total Factor Productivity, Canadian Metal Mining: 1967-1978

	Output per Man-Hour (1)	T.F.P.[1] (2)
(1) 1961-66	3.3	5.1
(2) 1967-73	4.4	3.0
(3) 1974-78	-2.1	-

Note 1. See Table II-2.

Source: C.H. Pye, *op. cit.*
Col. 1, pp. 78-79.
Col. 2, p. 84.

The important point to note in the data shown in Table II-3 is the fall off in output per worker after the mid seventies -- the same results we see in the Economic Council of Canada's studies. In fact Pye claims that his estimates indicate that productivity growth was slower in the seventies than in the sixties. Growth in the latter decade he classified as "strong growth".[5] He offers two reasons for this trend reversal. First, some metal mining industries, notably iron underwent extensive development, hence capital investment increased rapidly. This enlarged capital stock raised the capital-output ratio and hence lowered T.F.P. The second reason involves the reduction in ore grade mined. However, when properly included in the T.F.P. index, Pye claims that productivity decline is reversed as labour and capital productivity increased through the application of new technology -- new technology which was explicitly developed to reduce the effect of higher input costs associated with declining ore grade. The net effect of over-capitalization, excess capacity and labour efficiency due to technological change is never assessed by Pye, so we are left uncertain as to whether T.F.P. actually grew slower or even fell in the seventies vs the sixties. (The authors study on the Ontario metal mining experience -- reported on later in Chapter II -- suggests that the net effect was to flatten the growth of productivity in the seventies vs the sixties.)

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[5] C.H. Pye, op. cit., p. 72.

Statcan - Multifactor Productivity

The most recent excursion into this area of longer term multifactor productivity (M.F.P.) change is a study by Statistics Canada's Input-Output Division.[6] This work was delivered at the Annual Meetings of the Canadian Economics Association in May, 1984. Essentially this study follows the same methodology as the Economic Council of Canada's work by Postner and Wesa which was reviewed earlier in the chapter; i.e., an input-output table is used to calculate own-effect, input-effect and the total contribution of an industry to total M.F.P. change. These three terms are defined as follows:

Harrod MFP = own effect (or Hicksian MFP) + input effect

Total contribution = own effect + output effect.[7]

The Harrodian measure of MFP attempts to include the effects of technological change in the input industries; i.e., backward linkages, while the total contribution includes the productivity effect of the specific industry on other industries' performance. For example, the construction sector, since it influences a large range of other industries, generally has a large "output effect" even when its own-effect productivity performance is growing slowly.

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6 Alexandra Cas, "New Measures of Multifactor Productivity and Structural Change for Canadian Industries and Economy", Productivity Unit Input-Output Division, Statistics Canada, March 1984.

7 Alexandra Cas, op. cit.

Table II-4 sets out the rate of growth of output minus the weighted rate of growth of inputs which equals, by definition, M.F.P. The latter, in this case, is the own or Hicksian effect. Again the familiar drop in T.F.P. after the mid seventies is revealed. Cas suggests that for this sector, note it includes oil wells besides metals and non-metals, MFP declines very sharply after 1973. Here, however, it appears that on an own productivity basis the industry has experienced negative rates of MFP for the last two decades. By the late seventies this sector is included with the three or four poorest performing industries among the thirty-seven studied. Cas suggests that the poor performance is due to over capitalization in this industry spurred on by an array of government subsidies, taxation and depreciation allowances.

Before we conclude this segment of the discussion on other studies of productivity change in the mining sector we should compare the performance in the mining sector with several other sectors. The MFPs are set out in Table II-5. The conclusion is clear. Even though there has been a general slowdown in productivity growth since 1973 not <u>all</u> industries have experienced the type of performance witnessed in the mining sector. Less than expected world demand growth and government policies have apparently impacted negatively on the mining and petroleum sector.

TABLE II-4

Breakdown of the Rate of Growth of Hicksian MFP, for Mines, Quarries and Oil Wells, Selected Periods: 1961-1979

	Rate of Growth						
	Output	Intermediate Inputs	Intermediate Imports	Gov't Inputs	Labour	Capital	MFP Rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1961-71	6.33	-2.47	-0.38	-0.19	-0.37	-3.29	-0.36
1971-79	3.18	-3.97	-0.33	-0.18	-0.36	-2.24	-3.91
1961-79	4.93	-3.14	-0.36	-0.19	-0.36	-2.82	-1.94
1961-73	6.71	-3.09	-0.37	-0.23	-0.43	-3.03	-0.46
1973-79	0.32	-3.26	-0.32	-0.06	-0.19	-2.28	-5.79

Source: Alexandra Cas, *op. cit.*, "Statistical Appendix", Tables C-1 to C-5.

TABLE II-5

Annual Change in Multifactor Productivity for Selected Canadian Industries, 1973-1979

Industries	MFP
Textiles	2.19
Knitting Mills	4.29
Clothing	2.44
Machinery	2.41
Electrical Products	2.41
Petroleum & Coal Products	1.91
Railway Transport	3.11
Telephones	5.27

Source: Alexandra Cas, op. cit., Statistical Appendix, Table C-5.

Labour Measurement

Since our concern in this study is with the impact of labour costs on the performance of the mining sector and particularly on the metal mining industry in Ontario, it might be useful, at this stage to review how labour input was measured in the studies reviewed. Table II-6 draws this information together.

If labour's average factor share over the last two decades is roughly 40%, then one must be concerned with how this input is measured since it bears such an important weight in the estimation of total factor productivity. It is surprising, then, in reviewing how labour services are defined in these published studies to find how little agreement there is on the current measure for labour's input. Man-hours is apparently the preferred measure yet it is not always used. In addition none of the studies attempts to differentiate labour by skill even between white and blue collar workers. There is also no explicit recognition of the impact of indirect labour wage costs (i.e., payments in kind) on the wage bill, at least not in the studies outlined above. The authors of these works apparently continue to treat labour in its strict neo-classical view; i.e., as comprising homogeneous labour input earning an hourly income (direct pay) which is assumed to be equal to its cost to the employer, and as a completely variable factor of production. This study breaks away from such stereotyping.

TABLE II-6

Comparsion of Labour Measurement in Selected Studies of Productivity Change

Study (1)	Labour Measure (2)
(1) Postner/Wesa	(1) Man-year (2) Labour is treated as a homogeneous input
(2) Rao/Preston	(1) Man-hours (2) Average hourly earnings price of labour and the wage bill are taken from CANDIDE 2.0 databank. (3) Labour is treated as a homogeneous input
(3) Pye	(1) Man-hours (2) Labour is treated as a homogeneous input.
(4) Cas	(1) Total annual hours worked (not paid) (2) All labour was considered to be homogeneous

Sources:

(1) Postner and Wesa, op. cit., pp. 83 & 84.
(2) Rao and Preston " " p. 45.
(3) C. Pye " " p. 162.
(4) A. Cas " " p. 17.

Ontario Experience

To complete this review we look at the recent experience of metal mining in Ontario. To gain some perspective on this provinces' performance vis a vis the country as a whole results of an earlier study are summarized.[8]

The model used is a Cobb-Douglas production function which takes the following form:[9]

$$Y = A \cdot L^{\alpha} \cdot K^{1 - \alpha}$$

where Y = tons of ore hoisted

L = manhours of labour

K = real capital stock

A = a constant

α = factor share

In this particular form of production function α is assumed to be a constant. Thus $\alpha + 1-\alpha = 1$ and the production function is said to be homogeneous of the first degree. Under such conditions a doubling of inputs leads to a doubling of output or in other words there are no economies of large scale production.

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[8] Alan Green and Ann Green, "Wages and Productivity in the Ontario Mining Industry", forthcoming in Ontario Mineral Policy Background Paper, Ontario Ministry of Natural Resources.

[9] The form of the production function used here includes only two inputs -- capital and labour. The decision to exclude other inputs -- material and supply expenses and energy was done to simplify the discussion at this stage of our study.

This form of production function was chosen for three reasons. First, it is the least complex of later versions of production theory such as those outlined earlier and with the type of data available to us it seemed most reasonable to explore the full implications of this evidence as revealed in the Cobb-Douglas function before moving to more complex functional forms. Second, a study of factor shares for the metal mining industry in Ontario shows them to be roughly constant over our study period, particularly during the decade of the seventies. Third, given the assumption of constancy of factor shares one property of this functional form is that, when placed in index (change) form the average product of labour is equal to the marginal product of labour times α, a constant. This equality is useful to us when we compare changes in real wages with productivity changes in the industry.

In order to set out the general trends in output and inputs and measure productivity change over the last two decades the production function is transformed to the following:

$$\dot{Y} = \dot{A} + \alpha \cdot \dot{L} + \cdot 1-\alpha \cdot \dot{K}$$

The dots simply represent rate of change over time and are shown as indexes of the variables where 1971 is the base year; i.e., 1971 = 100.

Table II-7 sets out the change of output as measured in tons of ore hoisted and the two inputs: labour measured in number of manhours paid and real capital stock.[10] Although we are only showing

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[10] Although only trends between decadal points are shown here, data

TABLE II-7

Change in Real Output and Real Inputs Plus Capital/Labour Ratio Total Metal Mines, 1961-1977 (1971 = 100)

Year[1]	Output[2] (1)	Labour[3] (2)	Capital[4] (3)	K/L (4)
1961/62	67.3	112.8	82.9	3.35
1969/70	92.1	95.0	91.7	4.42
1976/77	93.3	94.0	86.5	4.19

Sources and Methods:

1. Figures are 2-years averages for the years shown.
2. Output is measured in terms of tons of ore hoisted.
3. Labour is measured in terms of number of manhours paid.
4. Capital is measured in terms of real capital stock.

Figures are derived from Ontario Metal Mining Statistics, Ontario Ministry of National Resources (Toronto: 1983).

trends between decadal points in order to simplify discussion we have data on an annual basis. The first point to note is the sharp break in output growth between the 1960s and the 1970s. In the former decade output growth was quite rapid; i.e., an increase of 25 index points, while the seventies witnessed virtually no expansion in production. This experience, of course, parallels that seen earlier for the country as a whole. Labour and capital growth did not parallel this change in output. In the 1960s, labour input declined by 18 index points while capital expanded by 9 index points. The seventies showed labour input levels remaining almost static while capital inputs decreased slightly. Given the way in which capital stock was estimated[11] it is probably the case that capital inputs remained roughly fixed over this second decade, as was the case for labour.

This differential experience between the growth of output and factor inputs, (see CHARTS II-1, II-2, II-3 and II-4 for annual changes), reveals itself clearly in the trend in the capital labour ratio (K/L), that is in factor intensity. During the sixties this ratio rose by 25 percent

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on an annual basis have been collected and will be reviewed later in this report.

[11] Real capital stock was derived from investment figures for the industry using the perpetual inventory method. The key parameter in this approach is the assumed service life of capital. After a careful review of the evidence 27 years was chosen. A caveat on the capital stock figures is necessary. Not only might the service life of capital be different from that assumed but published capital expenditure estimates might not capture all the additions to capital stock. For example part of development expenditures could be expensed to current operating costs and so escape detection. A solution to such problems is beyond the scope of the present study.

CHART II - 1

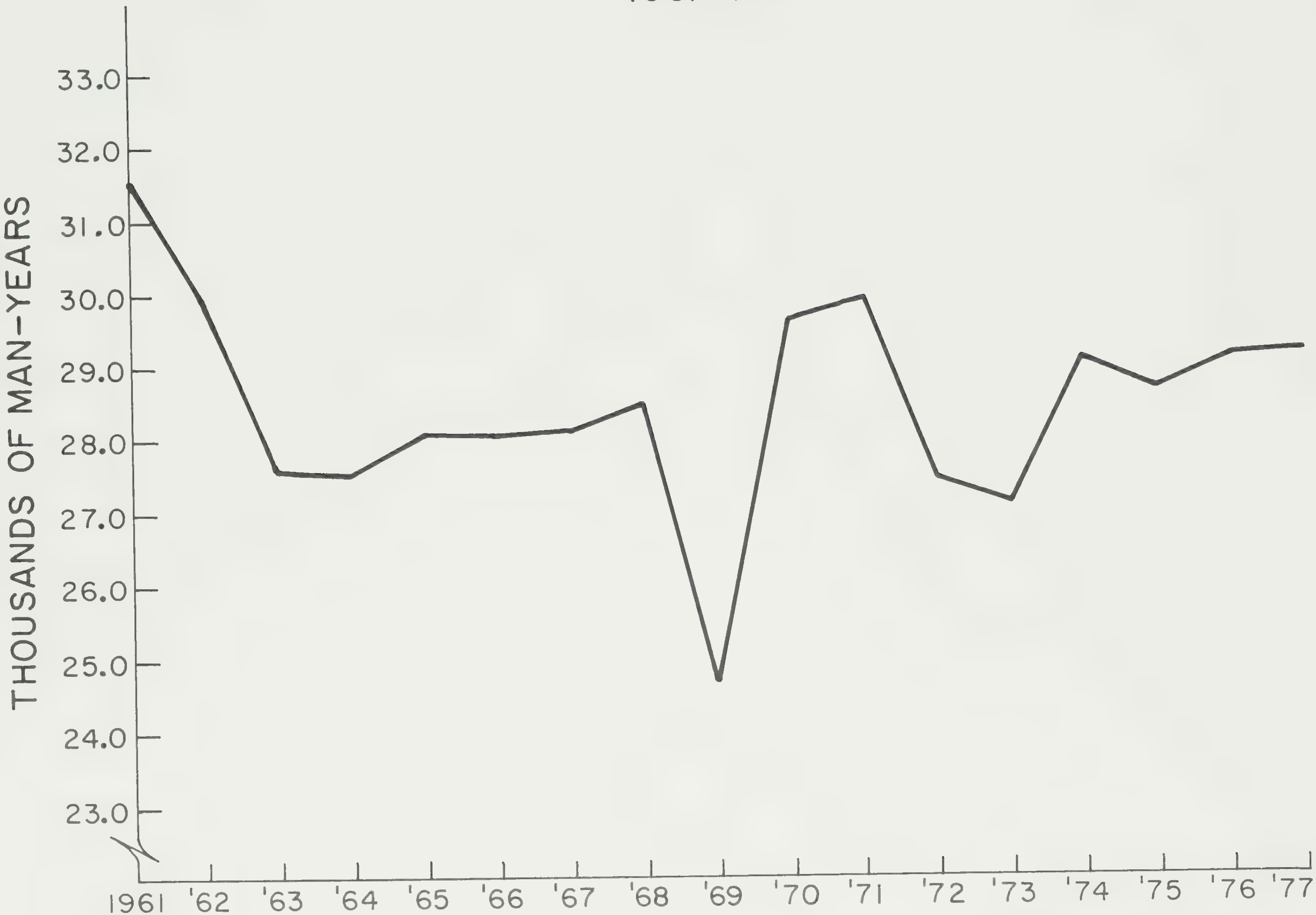
GROWTH OF REAL OUTPUT
ONTARIO METAL MINING INDUSTRY
1961-1977

SOURCE: APPENDIX TABLE 2

GROWTH OF REAL CAPITAL STOCK
ONTARIO METAL MINING INDUSTRY
1961 - 1977

SOURCE: APPENDIX TABLE 2

GROWTH OF LABOUR (MAN-YEARS)
ONTARIO METAL MINING INDUSTRY
1961 - 1977



SOURCE: APPENDIX TABLE 2

GROWTH OF LABOUR (MAN-HOURS)
ONTARIO METAL MINING INDUSTRY
1961-1977

SOURCE: ONTARIO METAL MINING STATISTICS p.64

while in the seventies it stayed relatively stable. This is an important finding since we normally associate technological change with a rise in the capital/labour ratio; i.e., a substitution of capital equipment for labour in the production process. This substitution of capital for labour raises labour productivity as both less labour per unit of output is employed and more output is produced. Increased factor intensity with respect to labour, therefore, apparently came to a halt in the seventies. This event, and its causes are unknown at the present time, had important consequences in productivity advance after 1970. Did this cessation arise from a slowdown in the growth of output or was it associated with the emergence of excess capacity due to previous capital expansion?

To see how productivity changed during the last two decades, labour and capital inputs, in index form, were divided into the output index. This exercise provides us with two measures of productivity, one for labour and one for capital; i.e., partial factor productivity indexes.

The results of this exercise are shown in Table II-8. For the decade of the sixties, when output was expanding rapidly and labour input was actually falling, labour productivity increased by 37 index points and capital productivity by 18 index points. Conversely when the growth in factor intensity is increasing K/L ratios came to a halt, labour productivity failed to increase and capital performance increased by only 8 index points. The decade of the seventies, therefore, can be characterized as one of near zero growth in productivity, at least as revealed

TABLE II-8

Partial Factor Productivity Change
Total Metal Mines, 1961-1977
(1971 = 100)

Year[1]	Labour Productivity[2] Y/L (1)	Capital Productivity[3] Y/K (2)
1961/62	59.6	81.1
1969/70	96.8	100.3
1976/77	99.3	107.9

Sources and Methods:

1. Figures are 2-year averages for the years shown.
2. Labour productivity is the output index divided by labour index. See Table II-7.
3. Capital productivity is the output index divided by the capital index. See Table II-7.

by these two partial factor productivity indexes.[12] This reinforces the point made earlier that the association in the rise of the capital/labour ratio can be taken as a signal that in effect change in the industry had slowed, if not come to a halt. More recent data may reveal that this condition is changing.

Our main interest in this study is with the relationship between productivity and labour rewards; i.e., the total labour costs incurred by the various firms. Accordingly then the relationship between wages and the marginal productivity of labour is important. Marginal productivity of labour measures the extra output obtained from the application of an additional unit of labour input. In theoretical terms this implies that the marginal product of labour equals the real wage rate.[13] Real wages, in this sense, are defined as money wages divided by the price index of metals for a given year. Metal prices were used as the deflator of nominal wages since theory indicates that the price of the final product is the appropriate index for such deflation.

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[12] This view of the industries performance in the seventies vs the sixties is consistent with the studies reviewed earlier although, for Ontario, the slowdown in productivity growth does not seem to be as extreme as, for example, that recorded by Alexandra Cas (see Table II-4).

[13] Marginal productivity of labour is defined as follows:

$$MP_L = \frac{dq}{dL} = \alpha \cdot A \cdot L^{\alpha-1} \cdot K^{1-\alpha} = \alpha\beta$$

where B = average product of labour. Since real wage equals the marginal productivity of labour then $W/P = MP_L = \alpha B$ where W = money wage rate; P = the selling price of the product.

As mentioned earlier one of the properties of the Cobb-Douglas production function is that, in index terms, average product equals marginal product. Hence one can compare directly the change in average product of labour with the change in the real wage rate. In the long run one would expect, according to theory that these two indexes should move together. However in the short run it is possible for real wages to either outpace or lag behind productivity change.

To study this connection between real wages and productivity, Table II-9 was constructed. This table shows, in index form, the change in the average product of labour (assumed equal to the marginal product of labour), and the real wage rate. During the decade of the sixties labour productivity increased by 37 index points while the real wage rate grew by 3 index points. During the seventies labour productivity rose by 2 index points while real wages increased by 10 index points. During the seventies real wages were advancing faster than the physical productivity of labour, especially in the last years of this decade, while they lagged behind increasing efficiency in the sixties. Something, then, changed in the relationship between wages and productivity over the two decades. It appears that during the sixties productivity increased faster than did nominal wages, while in the seventies this relationship was reversed. In addition the gap between real wages and measured productivity change, especially after 1970 is probably an underestimate of the true differential during the seventies since as we shall see in a later chapter, the ratio of indirect wage payments to direct wage payments rose

TABLE II-9

Average Product of Labour vs Change in Real Wage Rate (Index)
Total Metal Mines, 1961-1977
(1971 = 100)

Year[1]	Average Product of Labour Y/L (1)	Real Wage Rate[2] (Index) (2)
1961/62	59.6	81.68
1969/70	96.8	84.12
1976/77	99.3	95.40

Sources and Methods:

1. Figures are 2-year averages for the years shown.

2. Real wages were obtained by dividing the nominal wage rate by an index of metal prices.

dramatically during these years. Many of these later payments are not included in the wage rate shown in Table II-9.

If indirect wage costs were included wages would have outpaced labour productivity by an even greater margin.

To bring the findings on wage and productivity change into focus it might be helpful to express their interrelationship more precisely. From the Cobb-Douglas production function the following equation can be derived:

$$\dot{W} = \dot{B} + \dot{A} + \dot{p}$$

This equation, expressed in terms of rate of change per unit of time, states that the growth of nominal wages (W) is equal to the sum of labour's factor share change (B), growth in total factor productivity (A) and price changes (p). In the sixties and early seventies we found that productivity (A) increased faster than real wages (W-p) while this inequality was reversed in the seventies, especially after 1975. These inequalities imply that in the early years labour's share (B) should have fallen; i.e., $B < 0$ while in the seventies we would expect it to rise ($\dot{B} > 0$). The actual data confirm this hypothesis. Between 1961 and 1973 labour's share declined from .460 to .330 while from 1972 to the end of our period it increased from the 1973 low to .348. In terms of this type of analysis these are sizable changes and indicate, again, the major change in the relationship between wages and productivity that occurred during the last two decades.

What, then, is the link between real wages and productivity or, measuring wages in current dollars, between nominal wages, efficiency and commodity prices? The one point that seems to stand out in this analysis is the close association between commodity prices and nominal wages. In the sixties the selling price of minerals rose by 44 index points while nominal wages increased by 40 points. In the seventies the two series tracked each other even more closely; i.e., both rose about 80 index points between 1971 and 1977. Productivity, however, proceeded, as we saw, on its own path rising sharply in the sixties but hardly advancing in the seventies. Furthermore, as we noted earlier, wage increases in the seventies were accompanied by a major structural shift towards a much larger role for indirect wage payments.

These results on industry performance, wages and prices open up a series of important questions regarding the development of this industry over the last two decades. What conditions, for example, induced producers to undertake major capital investments in the sixties but brought this process to a halt in the seventies? Did the inducement to innovate emerge due to changing cost factors; e.g., the difficulty of hiring labour or was it in response to expanding demand for the industry's output? These are critical questions since we must know more precisely than we do now why industries and the economy cease, at certain periods, to advance technologically.

The other major question is the relationship between wage costs and the nature of total labour payments. Why, suddenly should an in-

creasing proportion of wage payments be made in kind rather than as direct wage transfers? Did this shift occur due to employers' desire to lock in workers, i.e., secure a stable labour force, or was the change a result of employee preference; i.e., escaping personal taxes, or finally are we observing simply the consequences of government decisions regarding safety, pensions, etc.

Answers to these questions are not easy. What follows in the balance of this report is a preliminary attempt, using micro-based evidence, to examine more closely the link between labour market decisions by Ontario metal mine producers and the nature of the market for their final goods. We begin with the simple expedient of partitioning the labour force between blue and white collar workers and by extending the number of directly measured factor inputs. The measurement of labour input, surely a critical feature in the mining sector's performance has, as was shown earlier, been a neglected area of inquiry.

CHAPTER III

STRUCTURAL CHANGE IN LABOUR INPUT AND PRODUCTIVITY CHANGE IN THE ONTARIO METAL MINING INDUSTRY

In the previous chapter it was suggested that one omission in recent studies on productivity change is in the measurement and interpretation of the service cost of labour. Almost universally labour is treated as a homogeneous input, undifferentiated by level of skill, schooling, etc., and assumed, implicitly, to be a variable factor input. This treatment is in sharp contrast to the work on capital which, in the past, has attracted a large amount of discussion, yet even in this case the input is treated as homogeneous. Rarely do we see capital segregated into fixed, working capital, by vintage, etc. For example, the effect of higher energy prices bears differentially on capital expenditures depending on whether they are intensive energy users such as is generally the case with old capital vs lighter energy users which occur with newer technology. In this chapter we begin to redress the treatment of labour by partitioning this factor into two broad categories -- production workers (B) and non-production workers (W). This will allow us to investigate how structural change in labour composition influenced observed productivity change in the Ontario metal mining sector since the early sixties.

Jorgenson and Griliches[1] state that nearly all change in real output can be accounted for by the growth of measured inputs -- if the latter are measured properly. Ernst Berndt[2] writing on the role of energy cost increases in the slowdown of productivity growth in U.S. manufacturing re-inforces this point by adding to the number of measured inputs; i.e., partitioning labour between white and blue collar workers and explicitly measuring energy inputs. He employs a net output (i.e., gross sales minus inter-industry purchases) approach in assessing the causes of productivity slowdown. These two studies together imply that, to obtain a true measure of partial and total factor productivity change requires an accurate measure of all inputs. In this study we focus on labour.

Denoting the quantity of labour as L, the real stock of capital as K, materials used M, energy consumed E, real output as Y and the state of technology as A, we set up a production function with the standard neo-classical characteristics including constant returns to scale. The generalized form then is:

$$Y = A[f(K,L,M,E)]. \tag{1}$$

Setting equation (1) in a rate of growth form yields the following:

$$\frac{\dot{Y}}{Y} = S_K \frac{\dot{K}}{K} + S_L \frac{\dot{L}}{L} + S_E \frac{\dot{E}}{E} + S_M \frac{\dot{M}}{M} + \frac{\dot{A}}{A} \tag{2}$$

where $\cdot$ = rate of change; e.g. $\frac{Y_t - Y_{t-1}}{Y_{t-1}}$

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[1] Jorgenson and Griliches, "The Explanation of Productivity Change", Review of Economics and Statistics, 1967.

[2] Ernst Berndt, "Energy Price Increases and the Productivity Slowdown in United States Manufacturing", Decline in Productivity Growth, Series #22, Federal Reserve Board of Boston (June, 1980).

S_K, S_L, S_E and S_M = the factor shares of capital, labour, energy and materials respectively.

Total Factor Productivity is:

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - S_K \frac{\dot{K}}{K} + S_L \frac{\dot{L}}{L} + S_E \frac{\dot{E}}{E} + S_M \frac{\dot{M}}{M} . \qquad (3)$$

It is Jorgenson and Griliches' view that, if we measure the observed inputs K, L, E and M accurately, then A, or technological change, would be much smaller than we observe it in most current studies.

In the analysis which follows total labour input will be divided into production workers (B) and non-production workers (W). The distinction between these two classifications is similar, but not exactly equivalent to, the division in industry between white and blue collar workers. It is similar since the method of obtaining the number of non-production employees is by subtracting the number of production workers engaged in what the Annual Census of Mines refers to as "Mining Activity" from the statistics on manpower counted under the heading "Total Mining Activity". The latter measures both production workers and non-production workers. It is probably the case, however, that some production workers include local mine office staff and indeed this figure might include technical support personnel as well.

The ideal unit of measure for labour input is the number of man-hours used to produce the observed level of output. Man-hours, unlike man-years, allows us to adjust the amount of input for mine closures (strikes, holidays, etc.), and for overtime. Man-years simply measures the input per individual assuming the worker is engaged in

production for say 2,000 hours in a given year. Unfortunately, we only have man-hour estimates for total labour input. When the latter is partitioned into production and non-production workers the statistics are recorded in man-years. However, as a supplement we have, from our sample survey, man-hours for these two categories from 1971-1979. The latter will be shown for comparison, but caution is needed in interpreting these man-hour figures since they are a sample of Ontario Metal Mining whereas the man-year figures are for the whole industry.

What, then, are the relative contributions of factor inputs to the total cost of production in this sector? Table III-1 sets out the six factor shares which include the break-down of labour into production and non-production workers. The first point to note is the role of labour in the total cost of production. Between 1961 and 1977 labour accounted for about 1/5 of total production expenses -- a share that remained relatively invariant over these two decades. Within the total labour bill production workers accounted for the largest component; i.e., accounted for about 75% of the total labour cost. An important feature here is the growth in the share of W which grew from 4.6% to 6.0%. Capital's share, which had risen to account for almost half of total costs by the early seventies, declined sharply in the last half of the decade.

It is worth mentioning, at this point, how capital's share was estimated. K is calculated as a residual. As such, then, it includes not only the returns to producers durables and non-residential construction but also returns which accrue to land, inventories and working

TABLE III-1

Mean Cost Shares OF K, L, B, W, E and M Inputs in Ontario Metal Mining: 1961-1977

Year	S_K (1)	S_L (2)	S_W (3)	S_B (4)	S_M (5)	S_E (6)
1961-71	.4266	.2123	.0458	.1665	.3407	.0222
1972-74	.4643	.1873	.0585	.1288	.3237	.0247
1975-77	.3984	.2095	.0598	.1497	.3554	.0367

Notation: K = aggregate capital and return to land
L = aggregate labour
W = non-production workers
B = production workers
M = aggregate materials and supplies
E = aggregate energy.

Source: Ontario Metal Mining Statistics, op. cit.

capital. If we can assume that half of capital services is absorbed in producers durables and non-residential construction, whose returns/or costs are largely fixed in the short term, then this sharp decline implies that the returns to land fell sharply over the study period. In mining the returns to land are an important but probably not separable component in the returns to capital.

Another way to observe this change in the industry's fortunes is to calculate a crude rate of return to capital. This is accomplished by taking total capital service costs (the residual) and dividing this figure by real capital stock. These estimates are shown in Table III-2. Although the ratio of return estimates must be treated with a degree of skepticism since residual estimates for capital service costs include not only the items listed above but, as it is estimated as a residual, it captures all the measurement errors in the other terms. Second, the capital service cost is not adjusted for taxes. Third, the real capital stock estimates were computed using the perpetual inventory approach. As mentioned in the previous chapter this method is sensitive to the assumed length of life of capital and if this is not assessed correctly it can affect the final estimates. The whole question of measuring real capital stock is in need of further research. Absolute levels, therefore, must be treated cautiously, hence we focus on trends.

With these caveats noted, then, the trend rates of return tell an interesting story. In the sixties, when real capital stock was expanding but total sales grew less rapidly, the rate of return increased

TABLE III-2

Rate of Return to Capital in the Ontario Metal Mining Sector
Annually: 1961-77

	Real Capital Stock (millions $) (1)	Rate of Return (2)		Real Capital Stock (millions $) (3)	Rate of Return (4)
1961	1,832	18.2	1969	1,924	20.6
1962	1,772	17.1	1970	2,057	23.8
1963	1,712	17.8	1971	2,173	16.7
1964	1,644	20.9	1972	2,202	20.5
1965	1,588	21.6	1973	2,110	38.1
1966	1,668	16.7	1974	1,914	41.5
1967	1,783	22.7	1975	1,844	45.3
1968	1,903	33.4	1976	1,865	46.5
			1977	1,895	41.0

Source: The Real Capital Stock series is in Productivity Change in the Ontario Gold Industry (available from the authors, at Queen's University).

slowly. However, in the seventies, despite the falling share of total capital service cost, the rate of return apparently increased. The latter occurred despite the increase associated with production worker costs, and the increased energy and materials bills. The main reason for the increase in the return was the interaction between a stable, to slightly declining real capital stock, and growing sales revenue, at least up to 1977. This stable capital stock suggests that the return to land accounted for much of the increase. Although evidence on the post 1977 period is not readily available one might assume that with increased costs plus a deterioration in international metal prices the rate of return trended downward after 1980.

Output vs. Input Growth

Before we review the underlying productivity measures, it might be useful to observe how other inputs grew relative to real output. Table III-3 sets out the growth of K, L, W, B, M and E plus the change in output (Y), where the latter is measured in tons of ore hoisted.

The most striking feature of this exercise is the decline in the growth of ore hoisted. Between 1972 and 1975, in fact, absolutely less ore was lifted than in the sixties. In fact the annual growth of ore hoisted in the seventies fell at a rate of 1.6% compared to a positive annual growth of 4.3% in the sixties.[3] This contrasts sharply with gross

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[3] Under an Hotelling rule we would expect as prices rose that mine operators would extract lower grade ores to maximize profits while

TABLE III-3

Average Annual Growth Rates of Quantities of Output and Inputs, Ontario Metal Mining Sector, 1961-77

	Y (1)	K (2)	L (3)	W (4)	B (5)	M (6)	E (7)
1961-72	2.50	1.68	-1.24	3.28	-2.14	4.78	9.03
1972-75	-1.39	-5.71	1.44	3.61	0.82	-1.32	2.60
1975-77	1.66	1.37	0.88	0.37	1.03	1.48	0.44

Sources: Ontario Metal Mining Statistics, op. cit.

Note: Y = real output (ore hoisted)
K = capital stock
L = man-years of labour
W = man-years of non-production workers
B = man-years of production workers
M = materials and supplies
E = energy.

revenue performance which increased about the same in the seventies (7.6%) as it did in the sixties (6.6%). Labour input growth changed dramatically, with W workers showing a steady decline while B workers fell in the sixties but resumed a small but positive increase in the seventies. In fact the number of production workers declined over the study period from 27,000 in 1961 to 22,600 in 1977 while non-production workers increased to 6,600 in the final year from 4,100 in 1961. The structure of labour input was clearly changing towards an increase in white collar workers -- i.e., labour input was shifting more towards a quasi-fixed factor of production, (for annual movements in these two categories of labour see Charts III-1 and III-2).

The growth of non-production workers relative to production workers is not unique to the Ontario metal mining industries. Berndt has shown a similar bias exists in the U.S. manufacturing sector.[4] The determinants of this growth in white collar workers, especially over a period of slower industry advance, are not yet clearly understood. The fact that the number of non-production workers continued to expand even when real output declined (1972-75) suggests that employers may have been engaging in labour hoarding over the business cycle. Another hypothesis is that the growth of W is related to the composition of output

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with falling prices owners would maximize the length of life of the mine. This whole question of maximizing present value of the ore deposit versus maximizing the life of the mine (ore body) is an important yet at this time unresolved controversy over production decisions.

[4] E. Berndt, op. cit., p. 67.

GROWTH OF NON-PRODUCTION (W) WORKERS IN MAN-YEARS
ONTARIO METAL MINING INDUSTRY
1961 - 1977

SOURCE: APPENDIX TABLE 2

GROWTH OF PRODUCTION (B) WORKERS IN MAN-YEARS
ONTARIO METAL MINING INDUSTRY
1961 - 1977

SOURCE: APPENDIX TABLE 2

and the nature of technology. More sophisticated equipment requires a different type of employee; i.e., engineers, technicians and their clerical support staff. Finally, the growth in government regulations, new tax and subsidy schemes, health and safety measures, pollution abatement legislation, etc., all add to the need for more non-production workers.

The question which arises from this finding is whether the growth in W relative to B was uniform across the metal mining industry. Table III-4 sets out this distribution for the iron, gold and "other" industries. "Other" industries include mainly nickel and copper producers.

Table III-4 is set out as the distribution of the total workers within a particular industry. Hence when a share grows it is equivalent to a growth rate greater than the total labour force. The patterns are quite interesting. In iron ore mining the share of non-production workers actually fell over the study period. This early decline for the iron ore industry may be due to the anticipated long-run decline in demand for this industry's output, at least for Ontario production. Thus the mine owners reduced staff associated with exploration and development work early. The opposite to this experience can be observed for gold and "Other" industries. It was the latter, however, where the largest changes occurred, and where the largest number of workers are concentrated. Hence a shift in this group exerts a major influence on the total movement of white and blue collar workers. The dominant firms in the "Other" category are large producers of nickel and copper. The implication is that it is the large firms where this shift towards

TABLE III-4

Average Share of Production and Non-Production Workers in the Gold, Iron Ore and "Other" Metal Mining Industries, 1961 to 1977

	Gold		Iron Ore		"Other"	
	L_B	L_W	L_B	L_W	L_B	L_W
	(1)	(2)	(3)	(4)	(5)	(6)
1961-72	.856	.144	.800	.200	.829	.170
1972-75	.842	.158	.818	.182	.745	.255
1975-77	.843	.157	.820	.180	.757	.243

Source: See Appendix Table 3.

non-production workers has been concentrated. Growth in non-production workers in this sector was most rapid in the period when real output growth was slowing. Again this suggests that some labour hoarding was apparently taking place, along with the other factors mentioned earlier.

Productivity Change

Using this measure of disaggregated labour input, total and partial factor productivity ratios were estimated for the Ontario metal mining industry. The share weights are those averages shown in Table III-1.

Some interesting results emerge in the calculation of partial factor productivity trends recorded in Table III-5. First, there has been a dramatic drop in Y/L between the first and the last periods, with the rate actually turning negative between 1972 and 1975. In the first period 1961-72 annual growth in labour productivity advanced at a rate of 3.74% a year while by the late seventies this rate had dropped to 0.78 percent a year. This is in contrast to our measure of total factor productivity (Col. 7) which actually increased over the study. If we disaggregate total Y/L into production (Col. 2) and non-production workers (Col. 3) the main conclusion is that neither the trend in blue nor the trend in white collar workers consistently contributes to the total labour performance. In the period 1961 to 1972 virtually all of the gain in Y/L is accounted for by efficiency gains in blue collar workers whereas between 1972 and 1975 productivity performance fell for both white and blue

TABLE III-5

Annual Movements in Different Measures of Productivity Change, Ontario Metal Mining Industry, 1961-1977

	$\frac{\dot{Y}}{Y} - \frac{\dot{L}}{L}$	$\frac{\dot{Y}}{Y} - \frac{\dot{L}_B}{L_B}$	$\frac{\dot{Y}}{Y} - \frac{\dot{L}_W}{L_W}$	$\frac{\dot{Y}}{Y} - \frac{\dot{K}}{K}$	$\frac{\dot{Y}}{Y} - \frac{\dot{M}}{M}$	$\frac{\dot{Y}}{Y} - \frac{\dot{E}}{E}$	$\frac{\dot{A}}{A}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1961-72	3.739	4.644	-0.778	0.820	-2.284	-6.528	0.161
1972-75	-2.826	-2.213	-5.003	4.320	-0.070	-3.988	1.304
1975-77	0.780	0.627	1.288	0.290	0.180	1.225	0.230

Source: See Table III-3.

collar workers, but mainly among non-production workers. In the last period (1975-77) both components contributed to the gain in Y/L.

The performance of capital productivity is fascinating. It exhibits a cyclical behavior, low in the first period; i.e., 0.820 per year (1961-72), rising dramatically to 4.32 percent a year in the second period and finally dropping sharply after 1975. In fact total factor productivity is positively associated with productivity change in capital. This is particularly evident in the middle period (1972-75). There is some indication, then, that a close association exists between capital stock change and T.F.P. An important component of the latter, besides changing size of plant, re-organization and improved labour quality, is technological change. Throughout these last two decades there has been a small gain from this residual element in productivity change. Recall that T.F.P. measures the gain to efficiency not accounted from the directly measured inputs (L_B, L_W, K, M and E) and hence it represents the amount of increase in real wages that can be obtained without undermining the economic viability of the industry. For example, wage increases in excess of this advance in T.F.P. must, then, be found from other surplus sources. In the case under review here this could occur by running down profits including the returns to land. In the metal mining industry real wages increased at an annual rate of 1.82% (1962-72); -7.40% (1972-75); and 8.54% (1975-77) over the study period. With the exception of the early seventies, real direct wage increases tended to run ahead of the T.F.P. growth, especially in the period after 1975.

A word should be said at this point on the measurement of capital. No adjustment to capital for differential cyclical utilization rates has been made. The Jorgenson-Griliches vs. Denison debate[5] suggests that an adjustment rate of utilization is probably a questionable procedure, for two reasons. First, how such a measure to adjust the slack to different utilization rates is to be made is not clear. In the U.S. horsepower used in purchased electricity was adopted to "deflate" capital utilization. It was not evident here how such a measure could be adopted. Second, one would also have to adjust for cyclical utilization differences in other quasi-fixed factors of production such as non-production workers. Again no single index to make such adjustments comes readily to mind.

Since energy usage has attracted so much attention in the last few years, the results on energy productivity shown in Table III-5 should be reviewed. In the period before 1975 when energy prices were relatively stable, energy inputs exhibited negative productivity performance. However, after 1975 when prices rose dramatically, energy productivity became positive. The implication is that demand for energy is price elastic. Hence as the price rose less was demanded, i.e. lower quantities per unit of output were used and hence energy productivity increased. Cost-based production function studies outlined in Chapter I provide additional evidence on this own-price elasticity of demand for energy. This is obviously another area (like capital measurement) that needs further investigation, given the expected long run trend in the real price

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[5] See U.S. Department of Commerce, Survey of Current Business, 1972.

of energy, especially in Canada where the domestic price of oil increased less than the world price.

The relationship between factor price and the change in quantity demanded is, as we saw in Chapter I, an important relationship in interpreting performance in any industry. Energy appears to be price elastic. To see how the factors move against price change, a simple descriptive set of regression equations were run where the prices of various factors were regressed on time. Similarly regressions were run on quantity changes against time.

The estimated regression co-efficients for factor cost and employment are shown in Table III-6, along with their respective standard errors. According to these estimates, the cost of capital rose at an annual rate of 5.5% a year while direct labour cost increased by 9.0% and energy by 3.0% annually over the test period. Such changes in costs should induce specific responses in relative factor input use. Panel B shows that capital stock grew at about 1.0% per year and energy usage grew at 8.8% while labour employment declined at the rate of 1.3% per year. Recall that if we had disaggregated labour into production and non-production workers, the latter would have had a positive coefficient.

A comparison of the three inputs, then, shows that the industry experienced a substitution of capital and energy against labour. This pattern is compatible with the relative factor cost performance, i.e. labour's cost increased relatively more rapidly than either that of capital

TABLE III-6

Annual Percentage Changes in the Costs and Employment of Capital, Labour and Energy Inputs in Ontario Metal Mining Industries: 1961-1977

(A) Costs

	ΔP_K	ΔP_L	ΔP_E
OMM	0.0547 (0.0042)	0.0897 (0.0040)	0.0300 (0.0145)

(B) Employment

	ΔK	ΔL	ΔE
OMM	0.0104 (0.00404)	-0.0129 (0.0027)	0.0878 (0.0078)

( ) = standard errors

where P_K = price of capital
P_L = price of labour
P_E = price of energy
K = real capital stock
L = man-hours employed
E = energy measured in B.T.U.'s.

or energy. The question that remains is whether the evolution of these factor proportions is due to pure factor substitution with a Hicks-neutral technological change; i.e., no bias towards capital or labour using or a combination of factor substitutions and Hicks-biased technological change -- a topic which is beyond the scope of this project.

Since our primary goal is with explanations for labour productivity change we can re-formulate equation 3 to highlight the factor impacting on labour's performance. Labour productivity can be shown to be the sum of total factor productivity plus the weighted sum of the growth of inputs relative to the growth of labour. The weights are the factor shares for K, E and M, in the case where labour is treated as a homogeneous input (see equation 4).

$$\frac{\dot{Y}}{Y} - \frac{\dot{L}}{L} = \frac{\dot{A}}{A} + S_K\left(\frac{\dot{K}}{K} - \frac{\dot{L}}{L}\right) + S_E\left(\frac{\dot{E}}{E} - \frac{\dot{L}}{L}\right) + S_M\left(\frac{\dot{M}}{M} - \frac{\dot{L}}{L}\right) \quad (4)$$

When labour is disaggregated into blue and white collar workers, respectively, equation 4 becomes

$$\frac{\dot{Y}}{Y} - \frac{\dot{L}_B}{L_B} = \frac{\dot{A}}{A} + S_K\left(\frac{\dot{K}}{K} - \frac{\dot{L}_B}{L_B}\right) + S_W\left(\frac{\dot{L}_W}{L_W} - \frac{\dot{L}_B}{L_B}\right) + S_E\left(\frac{\dot{E}}{E} - \frac{\dot{L}_B}{L_B}\right) + S_M\left(\frac{\dot{M}}{M} - \frac{\dot{L}_B}{L_B}\right) \quad (5)$$

for production workers and

$$\frac{\dot{Y}}{Y} - \frac{\dot{L}_W}{L_W} = \frac{\dot{A}}{A} + S_K\left(\frac{\dot{K}}{K} - \frac{\dot{L}_W}{L_W}\right) + S_B\left(\frac{\dot{L}_B}{L_B} - \frac{\dot{L}_W}{L_W}\right) + S_E\left(\frac{\dot{E}}{E} - \frac{\dot{L}_W}{L_W}\right) + S_M\left(\frac{\dot{M}}{M} - \frac{\dot{L}_W}{L_W}\right) \quad (6)$$

for non-production workers.

A caveat is necessary on the interpretation of these equations on labour productivity. The right hand side of the equations contains elements which "explain" observed productivity change on the left hand side. In a techincal sense, then, the right hand side partitions the growth of labour productivity into total factor productivity plus the sum of the weighted partial factor productivities. Although the right hand side explains annual percentage change, it should not be assumed that there exists a "cause" and "effect" relationship which runs in the same direction, since these equations are simply rearrangements of the basic T.F.P. identity shown earlier.

Table III-7 shows that, as noted before, aggregate labour productivity declined sharply over our study period. In the first period (1961-72), aggregate labour productivity grew at an annual rate of 3.7% -- surely a rate which is at or above the level for most industries during this period. Thereafter it fell sharply, actually turning negative in the middle period (1972-75) and regaining some lost ground in the last period, although still well below its initial level.

What explanations for this trend emerge from our data on equation (4)? First, the element which supported the strong initial surge in productivity was the growth in K/L during the sixties. Thereafter declines in aggregate labour productivity were associated with a sharp drop (even a reversal of trend from 1972 to 1975) in the growth of capital relative to the growth of labour input. Second, T.F.P. was a positive contributor to aggregate labour productivity performance over the whole

TABLE III-7

Factors Influencing Growth in Labour Productivity, Ontario Metal Mining Average Annual Growth Rates (in Percentage Points)

	$\frac{\dot{K}}{K} - \frac{\dot{L}}{L}$ (1)	$\frac{\dot{E}}{E} - \frac{\dot{L}}{L}$ (2)	$\frac{\dot{M}}{M} - \frac{\dot{L}}{L}$ (3)	$\frac{\dot{A}}{A}$ (4)	$\frac{\dot{Y}}{Y} - \frac{\dot{L}}{L}$ (5)
1961-72	1.245	0.173	2.052	0.216	3.868
1972-75	-3.318	0.029	-0.892	1.355	-2.826
1975-77	0.195	-0.016	-0.213	0.394	0.780

Source: See Table III-3

period, although, with the exception of the middle years, its role was fairly minor.

The role of energy in aggregate productivity performance is intriguing. Relative to labour force growth, it was slightly greater in the first two periods, giving some indication of energy/labour substitution. However, if we perform the same exercise with respect to capital the following emerges:

	$\frac{\dot{E}}{E} - \frac{\dot{K}}{K}$
1961-72	7.348
1972-75	8.308
1975-77	-0.935

During the period from the early sixties up to the mid seventies, when energy prices were rising very slowly, capital stock and energy usage grew rapidly, but energy more rapidly than capital. This suggests, but does not prove, that there was some energy/capital substitution taking place. After the rise in world energy prices both capital and energy growth declined sharply with energy falling faster. The suggestion is that before 1974 capital and energy may have been substitutes whereas after this date they became complements, i.e. a rise in energy prices cut the demand for this input <u>and</u> for capital. However, one must be cautious on this point since energy's weight in total cost (Table III-1) is so small that its influence on these observed trends in capital and aggregate labour productivity should not be pushed too far -- obviously the role of energy pricing in capital formation needs a closer look.

Table III-8 reports the results of a similar set of calculations to that set out in Table III-7 but now refer to the relationships set out in equations (5) and (6) for production (B) and non-production (W) workers. Partitioning change into B and W workers provides additional insight into the factors which influenced growth of aggregate labour productivity. First, the growth of non-production workers, for the first two periods, exceeded the growth in real output. Hence Y/W was actually negative between 1961 and 1975. Only in the last period, when the growth of demand slowed, did the annual percentage increase in non-production workers fall far enough to allow for a positive performance (i.e., 1.3% for the period 1975-77).

The performance of K/L_W was quite different over the test period from that for K/L or K/L_B. The latter two indices moved more or less in parallel, i.e. adding to their respective labour productivity growth rates in the first period and falling sharply in the last. For non-production workers the trend was reversed with the emergence of positive K/L_W rates after 1975 corresponding to a strong surge in non-production worker productivity.

Capital and non-production workers are often seen as complementary inputs to the production process and Panel B of Table III-8 seems to confirm this suspicion. Thus, in the sixties, when capital stock was accumulating rapidly, growth in non-production workers kept up with this growth, and indeed grew slightly faster. In the last period (1975-77), when capital stock growth was slow, so also was the growth of W workers,

TABLE III-8

Factors Influencing Growth in Production Workers (B) and Non-Production Workers (W) Productivity, Ontario Metal Mining Average Annual Growth Rates (in Percentage Points), 1961-1977

(A) Production Workers

	$\frac{\dot{K}}{K} - \frac{\dot{L}_B}{L_B}$	$\frac{\dot{L}_W}{L_W} - \frac{\dot{L}_B}{L_B}$	$\frac{\dot{E}}{E} - \frac{\dot{L}_B}{L_B}$	$\frac{\dot{M}}{M} - \frac{\dot{L}_B}{L_B}$	$\frac{\dot{A}}{A}$	$\frac{\dot{Y}}{Y} - \frac{\dot{B}}{B}$
	(1)	(2)	(3)	(4)	(5)	(6)
1961-72	1.631	0.248	0.248	2.360	0.161	4.644
1972-75	-3.033	0.163	0.044	-0.694	1.304	-2.213
1975-77	0.134	-0.040	-0.022	0.159	0.230	0.627

(B) Non-Production Workers

	$\frac{\dot{K}}{K} - \frac{\dot{L}_W}{L_W}$	$\frac{\dot{L}_B}{L_B} - \frac{\dot{L}_W}{L_W}$	$\frac{\dot{E}}{E} - \frac{\dot{L}_W}{L_W}$	$\frac{\dot{M}}{M} - \frac{\dot{L}_W}{L_W}$	$\frac{\dot{A}}{A}$	$\frac{\dot{Y}}{Y} - \frac{\dot{W}}{W}$
	(1)	(2)	(3)	(4)	(5)	(6)
1961-72	-0.682	-0.903	0.128	0.513	0.161	-0.778
1972-75	-4.329	-0.359	-0.025	-1.600	1.304	-5.003
1975-77	0.398	0.099	0.002	0.394	0.230	1.288

Source: See Table III-3.

i.e. the differential growth between these two inputs was less than a half a percent a year. The middle period is interesting since for reasons suggested earlier such as labour hoarding, plus increased government regulation, non-production worker growth substantially outstripped both growth in capital stock (col. 1) and in demand (col. 6).

If we treat capital and non-production workers both as complementary inputs and as quasi-fixed factors of production, an interesting story emerges on the growth of this sector. From the early sixties until the mid-seventies, the Ontario metal mining industry added substantially to its "holdings" of quasi-fixed factors of production -- a build-up one might say that appeared justified in light of the anticipated growth in demand for minerals. However, in the seventies this expectation was not realized. In our terms there emerged an exogenous decline in anticipated demand. Obviously in the short-run firms cannot adopt quickly the size of their plant (capital stock) to meet these altered market changes. Since W labour is complementary to capital, it took time to adjust the growth in this input to meet the new reality. Hence part of the reason for the sharp drop in aggregate labour productivity is the build up in earlier periods of quasi-fixed factors of production where productivity (i.e. that of K and W) fell as anticipated demand of the sixties failed to develop in the seventies.

CHAPTER IV

IS THE PRICE OF LABOUR THE TRUE COST OF LABOUR?

It has been a central position of this study that the elimination of errors in variable measurement is critical to a proper understanding of industry performance. For example, an underestimate of the rate of factor input growth, assuming output is estimated correctly, creates an upward bias in the rate of technological change, economies of scale, etc.; i.e. $\dot{A}$ (Total Factor Productivity) would appear to increase faster than its true value. The reverse, of course occurs if input growth is over-estimated. In Chapter III we set out measures of partial and total factor productivity growth for the Ontario metal mining industry using inputs measured in conventional terms. This chapter explores the growth of one input, labour, and seeks to improve the measure of its service cost. It is our contention that the service cost of labour, used up to this point, has been seriously underestimated due to the exclusion of indirect wages paid by the employer in the course of employing labour.

Direct vs Indirect Labour Costs

Before we begin to analyze the changing structure of the wage bill for the metal mining industry in Ontario, it might be useful to define direct and indirect labour costs as they are used in this study. Direct labour cost is generally referred to as an unconditional cash transfer. As such it refers to the gross pay (salary and/or wages) that the worker earns. In strict definitional terms it includes the following:

> Wages and salaries refer to gross earnings of employees before deductions for income tax and employee contributions to social benefits such as sickness, accident, unemployment insurance, and pensions. It includes all salaries, wages, bonuses, profits shared with employees, the value of room and board where provided, commissions paid to regular employees, as well as any other allowance forming part of the worker's earnings. Payments for overtime are included.[1]

As one can see from the definition direct wage payments are what we generally consider the "wages" paid to workers. There are two ways of expressing this cost, either as:

(a) Average Wage Rate; i.e., $\frac{DW}{L}$ (1)

or

(b) Wage Bill, i.e., $\frac{DW}{L} \cdot L$ (2)

where DW = direct wage

L = number of workers.

If we are primarily interested in the "price" of labour; i.e., relating the average wage rate (adjusted for price changes) to produc-

[1] Ontario Metal Mining Statistics, op. cit., p. 63.

tivity growth, then equation (1) is the appropriate index. In calculating total factor productivity we require an estimate of the total cost of labour to put with the cost of capital, energy, etc., i.e., the factor share of labour. In this case equation (2) is the appropriate measure.

As we saw in Chapters I and II, the wage bill employed to estimate either net output or cost equations generally uses the statistic defined in equation (2) where wages and salaries are measured in terms of the direct wage payments. To obtain some perspective on the growth of total wage payments (in current dollars), Chart IV-1 was drawn. In a study of productivity change up to the mid-fifties, direct wages probably were a good representation of the <u>cost</u> of labour to the employer since this was the major, if not the sole part, of the employer's payment to the employee. However, over the last quarter century a revolution has occurred in the structure of wage payments.

The main element in this structural transformation has been the rise of indirect labour costs. Indirect labour costs, often referred to as transfers-in-kind, include such items as vacations, pensions, life insurance, workmen's compensation, etc. These <u>fringe benefits</u> are interesting in their own right but they are also interesting for what they imply about wage cost, since these indirect payments have increased dramatically over time. The concern, then, is that they may not be fully accounted for in the compensation package paid to employees and so not recorded properly when used to define the total wage bill.

CHART IV - 1

GROWTH TOTAL WAGE PAYMENTS (TOTAL MINING ACTIVITY), TOTAL METALS, ONTARIO METAL MINING INDUSTRY 1961-1977

SOURCE: ONTARIO METAL MINING STATISICS p. 65

Theoretical Implications of Higher Real Wages

Before we begin to look at the actual trends in indirect to direct wages, it might be useful to examine the theoretical implications of higher wages on decision making for the individual (work-leisure trade-off); the industry; and finally the firm.

(a) Impact on the Individual (Work-Leisure Trade-off)

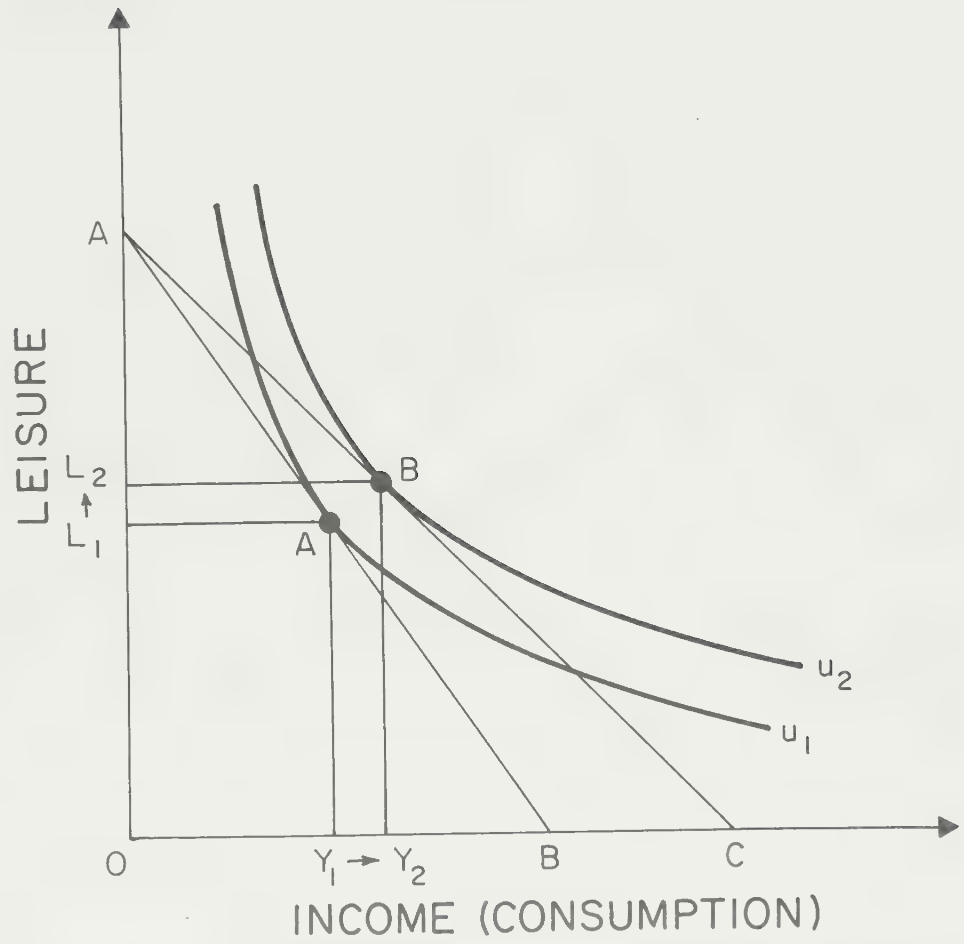
The exact impact of an increase in total wage income (direct plus indirect) is difficult to predict. One possible outcome is shown in Figure IV-1. This diagram sets out the standard utility maximizing choice an individual must make in allocating his time between work (income/consumption) and non-work (leisure). The budget constraint line (AB) is given by

$Y = W(24-H)$.

This equation shows how an individual trades off between work (24-H) and liesure (H), at a given hourly real wage (W). In Figure IV-1 the individual has chosen to work sufficient hours in the day to provide himself with an income of Y_1. Income level Y_1, then, defines his level of personal consumption.

If now we assume that his real income rises due to higher direct wages and additional entitlements for indirect payments, then the budget line AB rotates to AC. The individual then has a choice to make - expand his hours of work in response to the higher real wage or allocate more

FIGURE IV - 1



INCOME - LEISURE TRADE - OFF

time to leisure [non-work time (H)]. In Figure IV-1 the individual has chosen to increase non-work time (H); i.e., from L_1 to L_2.

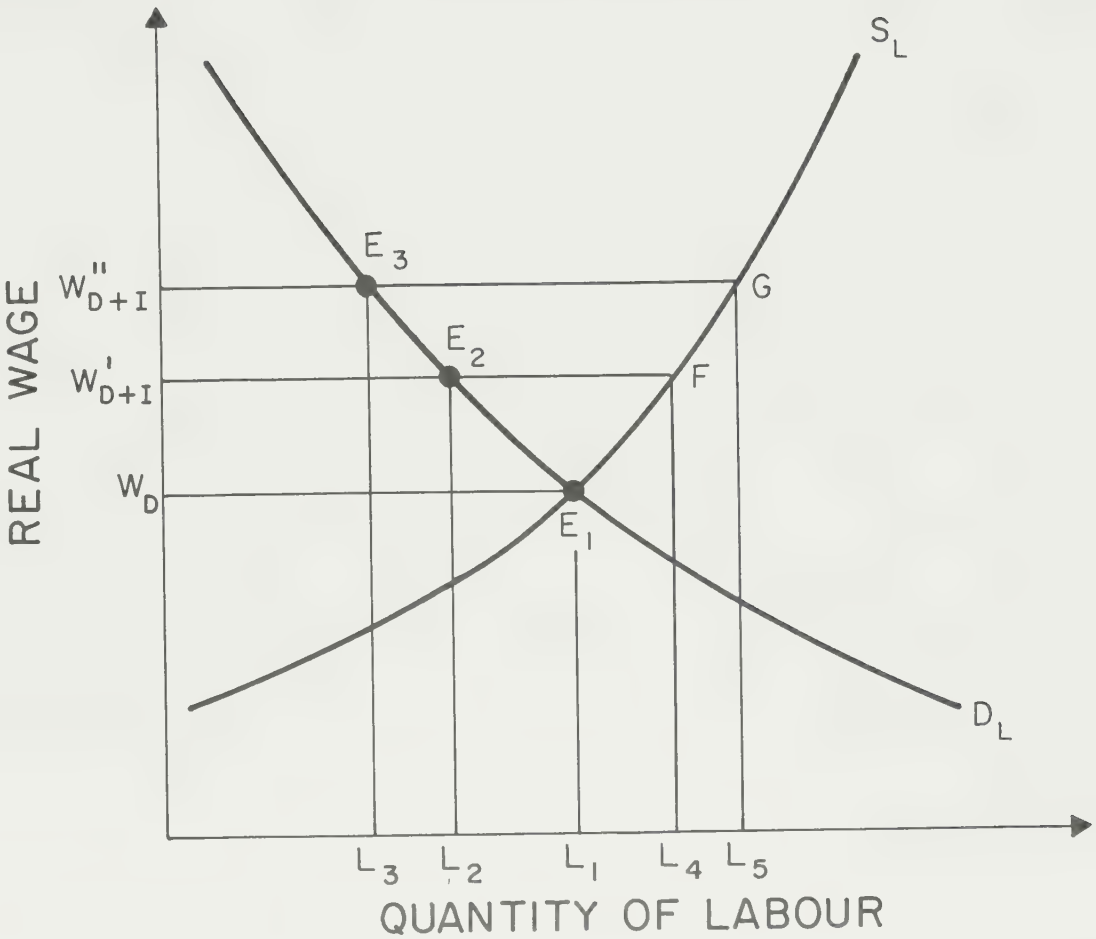
The implication, then, of a true measure of real income (direct plus indirect wages) on labour supply offered is critical. Part of the demands by unions for shorter work weeks, more pay for time not worked, early retirement, etc., are completely consistent with the outcome of increased real wages shown in our diagram. The point is that, to measure the intensity of these choices, one must take into account the full compensation package available to the employee.

(b) Industry Effects

What are the effects of higher real wages on the mining industry's choice on the number of workers to employ? To get some idea of the general directions Figure IV-2 has been constructed. This figure shows the amount of labour that will be demanded at various wage levels and the amount of total labour supply forthcoming at these various wage levels. Let W_D represent direct wages paid and W_{D+I} equal total employee compensation; i.e., direct plus indirect wages. The implication here is that indirect wages are rising faster than direct wages (i.e., pay for time worked -- the usual measure of the "price" of labour) hence pulling up the total cost of labour (W_{D+I}).

The consequences of this increase in the real cost of labour is quite dramatic. Assuming no change in labour's productivity; i.e., the

FIGURE IV - 2



INDUSTRY DEMAND AND SUPPLY CURVE OF LABOUR

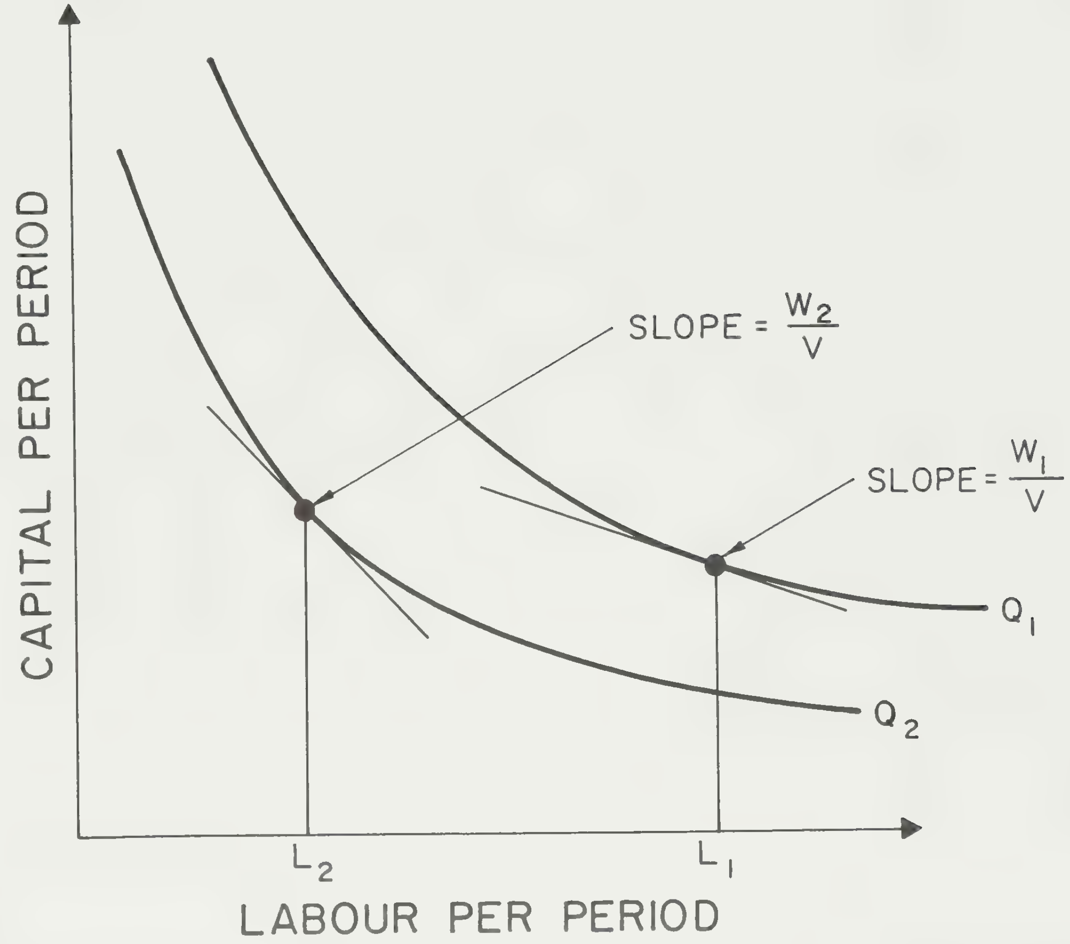
demand remains fixed, then rising labour costs leads to increased unemployment in the industry. Thus at a total labour cost of W'_{D+I} the amount of labour not employed is E_2F and at a total compensation of W''_{D+I} this increases to $E_3G(L_5-L_3)$. Here E_1, E_2 and E_3 are the equilibrium points. The effect of higher total labour costs coupled with a slow growth in labour productivity is for the industry (a) to reduce its level of output (here from L_1 to L_3) and (b) for some labour to go unemployed.

(c) Individual Firm Decisions

For the individual firm faced with these higher real wages the decision rests on the distribution of labour and capital which will be employed in producing a given level of output. Figure IV-3 sets up a simple neo-classical production function. The latter assumes that the individual firm has a large number of choices for which capital is to be substituted for labour with the exact choice dependent on the relative prices of capital (V) and labour (W). As shown in Figure IV-3 the impact of higher real wages, again due to an increase of wage reates and wage costs, means that the firm will reduce the amount of labour used (see Figure IV-3); i.e., lowering output from O_1 to O_2 and will, where the possibility exists, substitute capital for labour, hence lowering even further the amount of labour demanded.

Table IV-1 shows the growth of indirect wage payments in the Ontario metal mining industry and in manufacturing in Canada over the recent period. Both the level and trend in fringe benefits are interest-

FIGURE IV - 3



TYPICAL FIRMS RESPONSE TO AN INCREASE IN LABOUR COSTS RELATIVE TO THE COST OF CAPITAL

TABLE IV-1

A Comparison of Fringe Benefit Outlays[1] Between Ontario Metal Mining and Canadian Manufacturing Sector 1961-1976

	Ontario Metal Mining % (1)	Canadian Manufacturing % (2)
1961	16.3	23.4
1971	20.6	29.6
1977	43.9	32.1

Col. 1 Alan G. Green and M. Ann Green, Wages and Product-:ivity in the Ontario Mining Industry (Queen's, mimeo.).

Col. 2 S. Ostry and M. Zaidi, Labour Economics in Canada 3rd ed., Toronto, Macmillan 1979, pp. 202-203.

Note: (1) Fringe benefit costs are taken as a percentage of direct labour costs.

ing. By the late seventies indirect wages had grown to a third of direct labour costs in manufacturing and to more than 40% in the Ontario metal mining sector. They had become a significant item in wage cost. The other interesting feature is the difference in growth of this component. Ontario metal mining was slightly below the level of fringe benefits paid in manufacturing in the early sixties but by the end of the seventies their share exceeded that paid in manufacturing. Given their relative size, therefore, indirect labour costs must now be included explicitly in any discussion of wages paid, and in the wage structure.

Although it is not within the scope of this study to analyze the causes behind this rise in fringe benefits it is useful to question why employees and employers might move in this direction rather than simply place all wage increases in direct wage payments. In the latter (i.e., direct or unconditional wage payments), the employee has full discretionary use over his salary; i.e., how much to consume or save out of a given level of income. The balance between consumption and saving would obviously differ depending on the point in the individual's life cycle and since benefit plans are neutral with regard to age, they therefore impose costs on certain employees.[2] Morley Gunderson[3] has offered some

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[2] In addition to the life cycle inequities a re-distribution of indirect wage income can occur among employees where benefits occur to specific sub-groups of the labour force but which are not used by other workers. For example, the costs incurred in providing special housing to families mean that these "benefits" are fully discounted to single workers.

[3] Morley Gunderson, <u>Labour Market Economies</u>, McGraw-Hill Ryerson, Toronto, 1980, pp. 204-205.

possible reasons for this change in wage structure. On the employee side they include such reasons as tax savings, especially as tax rates have risen in recent times; economies of scale in the purchase of insurance, pensions benefits, etc; the belief on the part of employees that fringe benefits are "free" and if not taken the equivalent would not be paid in direct wages; to escape the direct effects of wage and price controls; and finally because they have a positive utility to the worker.

For the employer fringe benefits can have a different set of explanations. Employers benefit from having well defined paid vacations so they can schedule holidays to minimize production interruptions; workmen's compensation allows the employer to avoid setting up private schemes to aid the injured worker and employee benefits may well raise employee morale, so increasing productivity. Whatever the reasons for either employees or employers, indirect wages have become a very popular item during the last quarter century.

The problem, then, comes down to measuring, accurately, the true cost of labour to the employer. In pursuit of this goal we used the information on labour costs derived from a sample survey of Ontario metal mines. This survey covered the full range of minerals produced in the province. The information sought was an exhaustive listing of all wage related costs paid by the firms over a period of time stretching from the

mid fifties up to the late seventies. This survey covered both direct and indirect wage payments and their different sub-categories.[4]

To test for the validity of these sample results the values listed under the heading "pay for time worked", which was taken as equivalent to direct wage payments (wages and salaries as defined above), the gross payroll was divided by the average number of employees in the reporting firms and this ratio was compared to the average wages and salaries paid for the various metal industry groupings as recorded by Statistics Canada in their official publications for these industries. The results were consistently within about $200. The "sample" means run higher than the official estimates. This is the correct bias since the latter include items which are covered in wage categories other than direct wages in the sample survey. With this close agreement between the two direct wage payment measures we were certain that the other items captured in the survey (besides "pay for time worked") were indirect labour costs -- costs that were paid by the employer, but were not included under the wages bill in the official sources.

To demonstrate how indirect labour costs moved in relation to direct wages and salaries, Table IV-2 was constructed. In addition the annual movements of these variables, plus total wage payments, in terms of per worker cost is shown in Charts IV-2; IV-3: and IV-4. These

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[4] The reader interested in the full details of how the sample results were obtained is referred to Ontario Metal Mining Statistics, op. cit., Section 5, "Labour Cost Survey", pp 150 ff.

TABLE IV-2

A Comparison of the "Price" of Labour vs the "Cost" of Labour in Total, Gold and Iron and "Other" Metal Mining Industries, Ontario, 1961-1979

	Per Worker		
	Direct (1)	Direct + Indirect (2)	Ratio (2)/(1) x 100 (3)
		(A) Total Metal	
1961	4,710	5,598	118.9
1972	9,155	11,693	127.7
1975	11,608	15,899	137.0
1977	15,050	21,307	141.6
1979	14,160	20,499	144.7
		(B) Gold and Iron	
1961	4,214	4,852	115.1
1972	7,725	9,315	120.6
1975	11,484	14,465	126.0
1977	15,411	19,943	129.4
1979	18,244	24,024	131.7
		(C) "Other"	
1961	4,766	5,681	119.2
1972	9,235	11,829	122.8
1975	11,621	16,048	138.1
1977	15,007	21,409	142.7
1979	14,356	20,759	144.6

Source: See Appendix Tables 5, 6 and 7.

GROWTH OF TOTAL WAGE PAYMENT PER EMPLOYEE (DIRECT PLUS INDIRECT)
ONTARIO METAL MINING INDUSTRY
TOTAL METALS
1961 - 1979

SOURCE: APPENDIX TABLE 5

GROWTH OF DIRECT WAGE PAYMENTS PER EMPLOYEE
ONTARIO METAL MINING INDUSTRY
TOTAL METALS
1961 - 1979

SOURCE: APPENDIX TABLE 5

GROWTH OF INDIRECT WAGE PAYMENTS PER EMPLOYEE
ONTARIO METAL MINING INDUSTRY
TOTAL METALS
1961-1979

SOURCE: APPENDIX TABLE 5

estimates, for both the table and the charts, were obtained from the sample survey. Since the number of firms reporting information changed both from year to year and from commodity to commodity, the estimates were normalized by the average number of workers employed in the reporting firms. The three groups into which the sample is divided are (1) total metals (the whole metal mining sector); (2) gold and iron (combined here to avoid any breach of confidentiality); and (3) "Other" which includes silver, uranium, copper-lead- zinc and nickel-copper companies. The "Other" category includes a group of large firms while the gold and iron producers -- a group dominated by gold -- are generally smaller enterprises.

The general movement in the ratio of direct plus indirect to direct labour costs follows, for gold and iron and "Other", the trends as shown in Table IV-1. As the industry entered the sixties fringe benefits were only 16% of direct payments, and virtually all of this was accounted for by the gold and iron producers (the nickel-copper or "Other" producers apparently had very low levels of indirect payments during the early sixties). All of this changed dramatically over the next two decades. By 1977 virtually the whole growth in fringe benefit costs was accounted for by the "Other" industries' group which recorded ratios of 45% by 1979. Table IV-2 demonstrates that any inter-industry comparison of wage differentials must take account both of the different levels of indirect labour costs and the timing or rate of change in this type of wage compensation, before anything meaningful can be derived from such an exercise.

The extent of this surge in indirect wage costs in the seventies can be seen by comparing the relative growth of fringe benefits in the manufacturing sector over the same period. Total outlays on fringe benefits as a percent of direct labour costs for manufacturing were as follows:

Fringe Benefits as a % of Direct Labour Costs[5]

1971	29.6
1973	28.3
1975-76	31.1

As one can see, although there was a steady increase in the percentage of indirect labour costs over this period the acceleration in this component evident in the metal mining sector, did not emerge to the same extent in manufacturing. One might hazard a guess that as the terms of trade (metal prices relative to manufacturing prices) shifted towards the mining sector after 1974, the gains to exchange were increasingly taken out in a general improvement in time off, pensions, insurance and other transfers-in-kind. Why the sudden, and quite dramatic surge in the latter as compared to direct pay is unknown at this time. Workers apparently were anxious to "tie-up" their additional income gains in various benefit plans as opposed to more take-home pay. The latter (unconditional cash transfers) gives the worker full use of his earned income and hence, one would have thought, greater utility. Employers, obviously, were not about to disagree.

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[5] Source: See Table IV-1.

Distribution of Indirect Wage Payments

To obtain a clearer picture of the growth in indirect wage costs over the last two decades Tables IV-3, IV-4 and IV-5 were constructed. These tables show both the average cost per employee of the major categories of indirect labour costs or fringe benefits, and the annual compound rate of change of these different benefits for various sub-periods.

(a) Paid Time Off

Paid vacations are largely a phenomenon of the Post War Period. In earlier times when employees wanted time off they took it without pay. Hence in these earlier periods wages paid were directly related to output produced. Recently, as worker productivity rose, employees have been taking part of this gain in leisure (vacations, etc.) -- recall earlier theoretical discussion on on this topic, i.e., FigureIV-1. In addition to this negotiated time off the state has been gradually increasing the number of public holidays. Employees have also bargained for bereavement pay, special days off (on long weekends) etc. All of this time off has seen a sharp increase in employer expenses as more and more is paid for time not actually spent on the job.

This pay for time not worked is expensive. As Tables IV-3, IV-4 and IV-5 show by the late seventies the annual cost had risen to between $1300 and $1900 a year per employee (Panel A). If we look at the rates

TABLE IV-3

Level and Annual Rate of Change in the Direct Labour Costs and in the Major Categories of Indirect Labour Costs for Total Metal Mining, Annually, per Worker

				Employer Contributions	
Year	Direct (1)	Paid Time Off (2)	Other (3)	Required By Law (4)	Benefits Plans (5)
			(A) Level		
1961	4,710	329	24	190	345
1972	9,155	988	81	404	1,065
1979	14,160	1,900	361	1,394	1,684
			(B) Rate of Change		
Period					
1961-72	6.23	10.51	11.69	9.10	10.97
1972-75	8.23	17.96	14.94	31.56	10.52
1975-77	13.86	6.13	32.82	35.93	24.32
1977-79	-3.09	1.98	28.98	-10.43	3.35

Note: (1) Other includes such costs as non-production bonuses, profit sharing plans, savings plans, etc. For further detail see OMNR, Ontario Metal Mining Statistics, p. 152.

TABLE IV-4

Level and Annual Rate of Change in Direct Labour Costs and in the Major Categories of Indirect Labour Costs for Gold and Iron Industries, Annually, per Worker

Year	Direct (1)	Paid Time Off (2)	Other (3)	Employer Contributions: Required by Law (4)	Employer Contributions: Benefit Plans (5)
		(A) Level			
1961	4,117	177	5	366	75
1972	7,725	460	93	511	526
1979	12,502	1,336	1,143	2,021	1,280
		(B) Rate of Change			
Period					
1961-72	5.88	9.07	30.44	3.08	19.36
1972-75	14.13	13.81	59.30	37.55	4.31
1975-77	15.84	25.04	24.09	18.80	30.45
1977-79	-11.03	12.26	40.50	3.77	12.24

Notes and Sources: See Table IV-3.

TABLE IV-5

Level and Annual Rate of Change in Direct Labour Costs and in the Major Categories of Indirect Labour Costs for "Other" Mining Industries, Annually per worker

Year	Direct (1)	Paid Time Off (2)	Other (3)	Employer Contributions: Required by Law (4)	Employer Contributions: Benefit Plans (5)
			(A) Level		
1961	4,766	345	26	171	238
1972	9,235	1,019	80	398	1,097
1979	14,378	1,973	261	1,314	2,865
			(B) Rate of Change		
Period					
1961-72	6.20	10.35	10.76	7.98	14.90
1972-75	7.91	19.02	6.27	30.08	16.42
1975-77	13.76	5.00	39.19	38.64	23.54
1977-79	-2.20	2.06	18.46	-13.20	4.13

Notes and Sources: See Table IV-3.

of change (Panel B) we see how the patterns differ between industries. For gold and iron producers the annual cost increase has been high and steady (i.e., greater than 10% a year), whereas for "Other" producers there has been a steady decline in the rate of increase, although still positive over the whole period.

(b) Employer Contributions

(i) Required by Law

This category includes such items as unemployment insurance, Canada Pension Plan, workmen's compensation, etc. As society has shifted from a rural base where individuals were "protected" under an extended family system to an industrial/urban society comprising nuclear family units, the burden of meeting one's own needs increased. Hence governments became involved in offsetting major costs, for example, periods of unemployment, by creating the Unemployment Insurance Fund. To aid in retirement the C.P.P. was instituted. All of these social programmes imposed costs on employers, and on employees. The magnitude increased rapidly. In the early 1960s this cost to employers ran at $300 or less per employee. By the late seventies it had increased to between $1,300 and $2,000 per employee.

To get a closer look at the source of these cost increases, Table IV-6 was constructed. It shows that the major increases in these costs imposed by government legislation came in the early to mid seventies. They were part of the general expansion in costs that firms took on,

TABLE IV-6

Distribution of Payments Required by Law, In Cost Per Employee and Annual Rates of Change, by Major Component, 1961-1979

Year	Workman's Compensation (1)	Unemployment Insurance (2)	Canada Pension Plan (3)	Silicosis (4)	Other (5)	Total (6)
			(A) Level (Cost Per Employee)			
1961	127	45	-	14	-	185
1972	217	85	94	8	-	404
1979	914	170	150	34	14	1,282
			(B) Rate of Change			
Period						
1961-72	5.00	5.95	3.38[1]	-5.22	-	7.35
1972-75	30.11	22.95	8.47	80.43	-	28.43
1975-77	56.79	13.91	15.11	40.66	-	38.12
1977-79	-2.92	-9.81	-2.96	-	-	-10.06

Note: (1) Covers period 1966 to 1972.
Source: See Appendix Table 8.

either voluntarily or involuntarily, in these mid seventies years. The acceleration of costs associated with these government plans was added to the increased burden of fixed costs faced by the industry at this time. The expectation probably was that strong world metal prices would ease the cost burden. As we saw in the last chapter this did not come to pass.

(ii) Benefit Plans

These plans include such benefits as accrue under private pension plans, insurance and disability schemes, provincial medical plans, etc. The motivation for expenditure on these plans is similar to that outlined for "Payments Required by Law". The interesting feature is how fast they have grown. Costs per employee will of course, differ between industries depending on the nature of the workers' contracts. It is interesting to note, however, that, for the gold and iron industries, the average cost per employee is substantially lower than for the "Other" mining group. Gold producers are generally smaller enterprises than the firms in the "Other" category and this may have something to do with the observed differences in levels. In addition during these earlier years gold mining was a declining industry. Hence strong employee pressure for additional benefits may have induced employers to actually close operations. This possibility probably modified worker compensation demands at this time.

If, then, we total these employer contributions, the annual outlay is quite substantial, and it has grown rapidly since the early sixties. By the late seventies the combined categories (columns (4) and (5)) were averaging over $4,000 a year in benefit costs per employee. As Panel B of Table IV-3 shows the majority of this financial load was taken on between 1972 and 1977. After 1977, as conditions deteriorated, the rates of increase declined sharply. Indeed, for direct wages the numbers turned negative. The latter may be due to reduced overtime and bonus payments. It appears that in good times (the mid seventies) employees and governments opted for a sharply increased level of fringe benefits. This confirms, on the cost side, what we observed on the factor input side in the previous chapter, that over the last decade the fixed or quasi-fixed cost burden on the industry has increased sharply. This can be observed in these tables by comparing the last period (1977-79) with the immediately preceding periods (1975-77 and 1972-75). Growth in indirect labour costs actually turned negative but indirect labour costs continued to increase, although at a slower rate. Even in poorer times growth in indirect costs continued.

The real burden of these costs can be judged by comparing their annual rate of growth with the change in metal prices. This is not a definitive test since it implicitly assumes that all costs must be met by price increases for the final product. Such cost increases could be met, as well, by increased per worker productivity (see Chapter III).

The average annual change in metal prices during the period under review were as follows:

	% Change
1962-72	4.81
1972-75	19.44
1975-77	1.12

Generally the rates of increase in direct and indirect wage payments exceeded the growth in metal prices, except for 1972-75 when metal prices moved upward sharply, but the "Other" industries' direct and indirect wage increases were slightly less or about equal to this increase in metal prices. The general pattern of wage cost increases, however, follows the changing rate levels for metal prices. This is particularly evident after 1977. The main increase in costs however was taken on in the "golden days" of the early to mid seventies and had to be carried in the poorer times that followed. This again highlights the longer term effects of increasing the share of quasi-fixed costs in total costs.

Adjusted Measures of Factor Cost Shares

As mentioned at the beginning of this chapter the exercise here is to obtain a more accurate measure of labour costs. The evidence gathered suggests that the usual measure of labour cost -- the official figures on wages and salaries -- is much lower than the actual total cost to the employer when the indirect costs are included. Also our data show that this underestimate of total labour cost has grown substantially over

the recent past. Hence, omitting this finding means that the longer term movement in industry performance will be biased. Until the necessary calculations are undertaken, the exact nature of the bias cannot be known.

To get some perspective on how factor shares are influenced by the revised measure of total labour cost, Table IV-7 was developed. The table is a "construct" in the sense that adjustments were made to the original wage bill; i.e., to the wage bill shown in the preceding chapters. These took the following form. First, ratios of direct plus indirect wage payments to direct wage payments were calculated annually from 1961 to 1977, (See Table IV-2). Second, these ratios were then multiplied by the wage and salary bill used in earlier chapters to calculate labour's factor share. The resulting product is the adjusted wage and salary bill shown in col. (5) of Table IV-7. As in the previous estimates of factor shares the sum of materials, energy and, now the adjusted labour force shares, were summed and subtracted from one to give the new capital share (col. (2) of Table IV-7). The assumption, as mentioned at the start of Chapter III, is that the industry faces constant returns to scale. The validity of this assumption is easily tested by regressing labour and capital inputs on real output and estimating the respective coefficients. This has not been done for this study but might serve as the focus for additional work in this area.

The most important finding of this reworking of factor share distributions is the altered role of labour in total cost of production.

TABLE IV-7

Unadjusted and Adjusted Mean Cost Shares of K,L,M and E,

Total Metal Mining, 1961-77

	S_K		Percentage Change Col. (2) to Col. (1)	S_L		Percentage Change Col. (5) to Col. (4)	S_M	S_E
	Unadj.	Adj.		Unadj.	Adj.			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1961-71	.4266	.3836	-10.0	.2123	.2535	19.4	.3407	.0222
1973-74	.4643	.4048	-12.8	.1873	.2467	31.7	.3237	.0247
1975-77	.3984	.3155	-20.0	.2085	.2925	40.3	.3554	.0367

Notes: UNADJ = unadjusted factor share

ADJ = adjusted factor share

Sources: Cols. (1), (3), (5) and (6), Table III-1.

Cols. (2) and (4), Appendix 9.

Using the conventional measure of labour's service cost meant that labour's share never got above approximately a fifth of total production cost. Under the revised figures, where indirect wage costs are explicitly included, labour's factor share rises to almost thirty percent of total cost -- a jump of approximately 40% by the late 1970s. Since we are assuming constant returns to scale this means that capital's factor share has declined sharply from approximately 40 percent to 32 percent by 1977.

These factor share changes constitute a major alteration in our perception of the metal mining industry. First, they show that as we get closer to the present, labour's share is much larger than was assumed in earlier studies. In fact by the late seventies it is on par with capital's contribution to total cost. This has important implications for the future technological development of the industry. Certainly it is the case that capital has been substituted for labour in the past as the price of labour rose relative to the price of capital. Now, however, an additional imperative has been added; i.e., that labour's share weight equals that of capital. The combination of equal share weight and rising relative factor prices (for labour) has the potential of biasing technological change towards a more capital-using set of techniques than was the case in the past (see Figure IV-3). Firms have a double incentive to conserve on labour's input; i.e., price of the factor, <u>and</u> its weight in the total cost of the operation. This increased weight, furthermore, is a fairly recent phenomenon yet appears to be in place for the future. One suspects, however, that the share of indirect to direct labour costs will not rise much further, although we have no theory to tell us what the optimal

or ultimate wage structure might look like. If factor price ratios were to reverse one might observe some back switching towards more labour intensive production.

The other major implication that emerges from this finding is the impact the proper measurement of labour's cost share has on the estimation of cost and net output functions. Recall that in estimating the parameters for the translog cost function the basic estimating equations have, as their dependent variable, the input factor shares. We are interested in relating relative factor share prices, time, etc., to the observed change in these factor shares. Out of these regressions emerge estimates of own and cross-price elasticities of demand. The altered position of labour's factor share must now be tested to see how these parameters are influenced by this larger labour cost figure. This is important for studies using data for the last 10 to 15 years since as, we can see, labour's factor share has changed dramatically over this period as the result of the growing demand of workers for transfers-in-kind payments as opposed to unconditional cash transfers (direct wages).

The case for re-estimating T.F.P. in light of these new findings is just as strong as for the cost function estimates. As we saw in Chapter III, T.F.P. is influenced by the weighting pattern used to sum the measured inputs. In the late seventies labour input flattened, yet the labour share in total cost actually increased. A hard decision must be made, then, as to which set of factor shares to use; i.e., one for each

subperiod, an average over the whole period; or one covering the more recent experience. Regardless of which distribution is ultimately chosen, labour's adjusted share will be larger and hence might potentially affect the rate of change of T.F.P. The main impact of this change in the measure of labour's share would seem to be a problem of more recent times.

What are the implications of these changes for rates of return to capital? In Table III-2 we estimated a crude returns' ratio using capital's factor share and dividing this by the real capital stock. Since capital's factor share is computed as a residual then it includes not only returns to capital but to land, working capital, inventories, etc. It is also a before tax rate of return. Table IV-8 and Chart IV-5 compares the unadjusted with the adjusted capital share.

The main conclusion from this exercise is that when properly measured the rate of return to capital in the Ontario metal mining industry is lowered, and by the end of the period by a quite substantial margin; i.e., for the period 1975-77 the reduction, on average, is about 20%.

This is a major revision in our understanding of the potential returns to investment in this sector. The level itself might be called in question, but the finding that the downward revision is greater by the end of the period than in the first three years suggests that a new view on these costs is essential.

TABLE IV-8

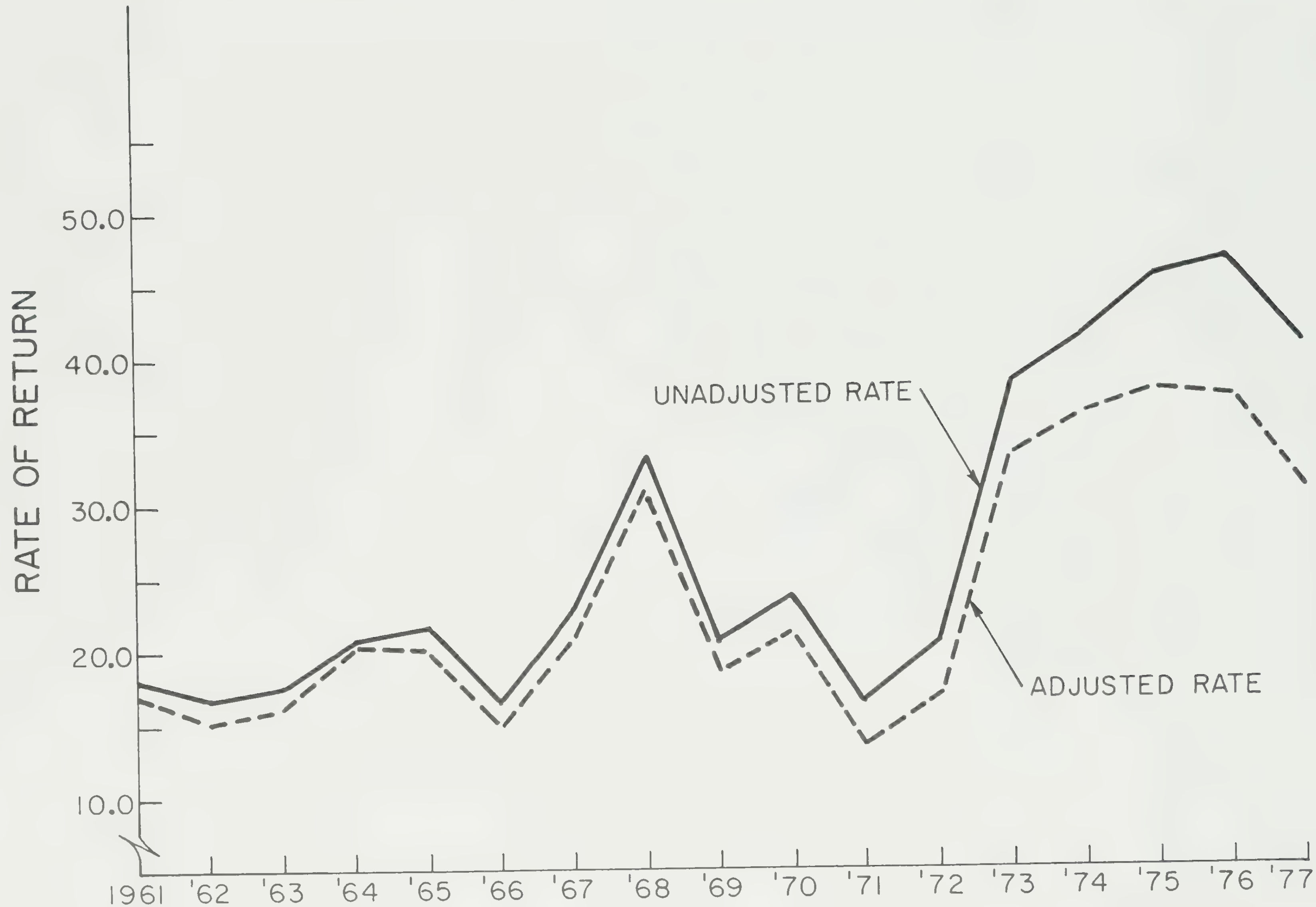
A Comparison of the Rate of Before Tax "Return to Capital"[1] in the Ontario Metal Mining Industry, Adjusted vs Unadjusted Capital Share, Annually, 1961-77

	Rate of Return to Capital	
	Unadjusted (1)	Adjusted (2)
1961	18.2	17.2
1962	17.1	15.3
1963	17.8	16.2
1964	20.9	20.5
1965	21.6	20.0
1966	16.7	15.0
1967	22.7	20.8
1968	33.4	31.4
1969	20.6	18.8
1970	23.8	21.1
1971	16.7	13.5
1972	20.5	17.0
1973	38.1	33.0
1974	41.5	35.9
1975	45.3	37.5
1976	46.5	37.0
1977	41.0	30.5

Source: See Appendix Table 9.

Note: (1) This ratio includes rent as well as the return to fixed capital. It is not a simple accounting profit.

A COMPARISON OF ADJUSTED AND UNADJUSTED RATE OF RETURN TO CAPITAL
ONTARIO METAL MINING INDUSTRY
1961 - 1977



SOURCE: TABLE IV-8

Hence we have the interesting finding that during the seventies anticipated rates of return were falling further below expectations not only due to the general state of demand but due to the rising cost of factor inputs, especially labour.

Further this drop in the rate of return implies, as we suggested earlier, that part of these increased costs were drawn from profits and the returns to land. This hypothesis emerges from the finding that the real capital stock in the sector ceased to expand in the seventies, hence the total returns component going to fixed capital must have been fairly stable. The reduction, therefore, probably came from lower returns to land; i.e., part of the surplus from the latter was shifted to profits and part to higher labour costs. This is one area which quite obviously needs further investigation for it is at the heart of our understanding of the future development of this industry.

CHAPTER V

SUMMARY/CONCLUSIONS/RECOMMENDATIONS

I. Summary/Conclusions

The central goal of this project was to review the inter-relationship between prices, wages and productivity in the Ontario Metal mining industry. Within this broad mandate special reference was made to the measurement of labour costs, especially the growing role of indirect wages or fringe benefits. An important impetus for this study was the data derived from a special labour cost sample taken of Ontario firms operating in this sector. The period of study was limited to the last two decades -- a limitation imposed by the availability of data.

A review of studies dealing with the Canadian mineral industry plus a new estimate of multi-factor productivity in the Ontario metal mining industry revealed the following:

(1) The decline in multifactor productivity (MFP) began earlier than has been assumed in recent literature. The downturn apparently began in the early seventies rather than in the eighties.

(2) The intensity of the downturn in this industry was among the worst experienced in Canadian industry.

(3) It seems likely that the main reason for this downturn in MFP was an unanticipated slowdown in worldwide demand for minerals. The cause, then, was more a lack of markets than a short fall in investment.

The important question which emerges from these findings is why the industry failed to adjust more easily to changing international market conditions. Large swings in economic fortunes are the hallmark of any resource-based industry especially in the Canadian case where the exposure to the vagaries of the international market is so large. Several studies reviewed in this paper -- studies which estimated a cost function for the industry -- suggested that the own-price elasticity of demand for labour was about the same as in the manufacturing sector as a whole. Furthermore it is the case that cross-elasticities of demand are what we normally expect; i.e., that capital and labour are substitutes.

The main conclusion from these findings is that the industry had become less flexible in its ability to adapt to market conditions. To test this hypothesis two experiments were undertaken. First, labour input was divided into two broad categories -- production workers (B) and non-production workers (W). It was our contention that a rapid growth in W workers had the same effect as adding to the stock of fixed capital; i.e., it added to the supply of quasi-fixed factors of production. Chapter III re-estimated MFP with this division and found that, indeed, W workers did grow more rapidly than B workers over the test period <u>and</u> the increase in W workers tended to lower labour productivity.

The second thrust was to examine the cost of labour to the industry (Chapter IV) since, as mentioned above, there was the suspicion that these expenses were underestimated. An examination of our sample survey proved this to be the case. The results showed:

(i) Indirect labour costs (i.e., pensions, pay for time not worked, workmen's compensation, health plans, etc.) grew faster than did direct wages (take-home pay). By the late seventies indirect wage costs, in this industry, were about 40% of the direct wage -- up from 16% in the early sixties.

(ii) This increase in indirect wage costs was largely concentrated in the early and mid seventies, when the terms of trade were running in favour of the mining sector.

(iii) The increase in indirect labour costs was not uniform across all firms in the industry. Indirect labour costs as a share of direct wage payments rose more rapidly in the larger firms.

The sample allowed us to estimate the total cost of labour to the firms since information was gathered on both direct payments and employer costs associated with indirect wages or fringe benefits. With these cost data, labour's factor share in total cost was re-estimated. The re-

sults showed that by the late seventies labour's share was under- estimated by close to 40%, and its share equalled that of the service cost of capital. Capital's factor share throughout the study was estimated as a residual; as such it captured not only the service cost of capital but also profits, the returns to land and to working capital. The re-estimated capital share, when divided by real capital stock indicated that returns to capital were apparently lower than was originally assumed when the cost of labour was underestimated.

A simple overview of the last decade and a half in this sector would suggest the following interpretation. In the sixties the industry invested heavily in new capital equipment thereby adding to its potential efficiency but also increasing sharply its fixed costs of production (interest payments) and the supply of quasi-fixed factors of production. The seventies saw an almost complete reversal of capital expansion. This was replaced by a sharp rise in labour costs, especially indirect labour costs and rapid growth in non-production workers. These latter changes added further to the fixed or quasi-fixed costs facing the industry. Apparently these costs were paid for from profits and returns to land. The main problem came when the anticipated demand, and accompanying strong commodity prices, failed to emerge during the late seventies and early eighties. The result was that with larger fixed obligations plus excess capacity, productivity fell sharply. Wages, prices and productivity were indeed tied closely together.

II. Recommendations

(a) Policy

For an industry which has traditionally faced highly uncertain international markets and now must add to that a whole new array of competitors (which tends to flatten even further the slope of the industry's demand function), there is a critical need to introduce more flexible operating arrangements. Two suggestions following from this are:

(i) To begin re-orienting the wage structure away from such a large component of indirect labour costs. Future wage contracts should aim to reduce the ratio of indirect to direct wages. At least the share of indirect wages to direct wages should be brought closer to that in manufacturing. This might prove difficult, however, in light of government initiated increases in workmen's compensation payments which are expected to rise sharply in the near future.

(ii) The extent to which capital is substituted for labour should be reviewed so that greater use can be made of new technology. It is even more the case when labour's cost is measured accurately that capital's price is growing less rapidly than that of the cost of labour. Apparently the mining industry will have to become even

leaner in terms of its use of labour than it is at present.

These recommendations are premised upon a continuation of past trends in social, fiscal and labour policies. To provide for the implications of possible change in policy direction industry might well consider utilizing scenarios allowing for technological backswitching.

(b) Research

(i) It is imperative that these estimates be updated so that the implications of recent market conditions and employer decisions can be studied.

(ii) In light of the new findings on the full cost of labour, study should begin on re-estimating cost functions in order to investigate the true own and cross price elasticities of demand. Knowledge of these elasticities is essential in light of recommendation (a).

(iii) Work should be started on estimating a more accurate measure of capital. Again it is imperative to know (a) the size; (b) the vintage and (c) the composition of capital stock in this industry.

(iv) Further work should be undertaken on the current wage structure in the industry to examine how longer term trends in falling MFP have influenced this factor's behaviour.

APPENDIX TABLE 1

Cost Shares of K,L,B,W,E and M Inputs in Ontario Metal Mining 1961-1977

Year	S_K (1)	S_L (2)	S_W (3)	S_B (4)	S_M (5)	S_E (6)
1961	.4790	.2220	.0395	.1825	.2773	.0216
1962	.4541	.2316	.0437	.1879	.2913	.0230
1963	.4643	.2210	.0454	.1756	.2917	.0229
1964	.4843	.2078	.0425	.1654	.2859	.0219
1965	.4517	.2064	.0422	.1642	.3204	.0215
1966	.3932	.2316	.0489	.1826	.3558	.0194
1967	.4278	.2005	.0439	.1566	.3580	.0136
1968	.4312	.1939	.0382	.1588	.3526	.0223
1969	.4019	.1900	.0464	.1436	.3812	.0269
1970	.4012	.2000	.0515	.1484	.3958	.0235
1971	.3040	.2303	.0615	.1688	.4377	.0280
1972	.3747	.2282	.0635	.1646	.3682	.0289
1973	.4797	.1811	.0601	.1211	.3166	.0226
1974	.5384	.1526	.0518	.1008	.2864	.0226
1975	.4266	.1984	.0575	.1408	.3443	.0306
1976	.4053	.2063	.0583	.1480	.3523	.0361
1977	.3634	.2238	.0636	.1602	.3696	.0433

Notation: K = total capital including return to land
L = total labour
W = non-production workers
B = production workers
M = materials and supplies
E = energy

Source: Ontario Metal Mining Statistics, op. cit.

APPENDIX TABLE 2

Quantities of Output and Inputs, Ontario Metal Mining Sector, 1961-77

Years	Y thousands of short tons (1)	K millions of $ (2)	L man years (3)	W man years (4)	B man years (5)	M thousands of $ (6)	E millions of B.T.U.'s. (7)
1961	46,045.2	1,832.80	31,505	4,147	27,358	85.38	11,986,210
1962	42,083.3	1,772.17	29,963	2,148	27,815	81.10	11,175,220
1963	39,019.1	1,711.71	27,647	4,152	23,495	77.88	11,172,210
1964	42,410.6	1,644.16	27,561	4,095	23,466	82.62	11,582,500
1965	48,286.6	1,588.09	28,090	4,240	23,850	96,93	12,628,840
1966	45,130.8	1,668.52	28,050	4,367	23,683	94.41	14,097,310
1967	51,858.1	1,782.80	28,131	4,884	23,247	127.99	19,140,620
1968	61,972.8	1,903.20	28,458	4,534	23,924	137.90	24,684,610
1969	53,482.0	1,924.65	24,728	4,300	20,428	133.45	25,911,280
1970	67,151.1	2,056.90	29,637	6,325	23,312	177.12	29,026,800
1971	65,517.1	2,173.28	29,880	6,020	23,860	180.84	30,714,310
1972	60,401.9	2,202.16	27,469	5,913	21,556	142.77	31,018,440
1973	62,047.1	2,110.52	27,147	6,266	20,881	140.62	30,519,760
1974	62,608.1	1,914.16	29,036	7,549	21,487	136.67	34,759,030
1975	57,908.8	1,843.98	28,671	6,578	22,093	137.19	33,500,040
1976	61,360.2	1,865.42	29,054	6,479	22,575	147.17	37,119,580
1977	59,852.2	1,894.87	29,178	6,626	22,552	141.28	33,792,360

Notation: Y = total output of ore hoisted
K = real capital stock
L = total labour
W = non-production workers
B = production workers
M = materials and supplies
E = energy

Note: Col. (2): The method of estimating the real capital stock can be obtained from the authors at the Department of Economics, Queen's University.

Source: Ontario Metal Mining Statistics, op. cit.

APPENDIX TABLE 3

Production and Non-Production Workers in the Gold, Iron Ore and "Other" Metal Mining Industries, 1961-1977

Year	Gold		Iron Ore		"Other"	
	B	W	B	W	B	W
1961	9,946	1,461	1,852	361	15,560	2,325
1962	9,487	1,475	1,806	369	14,522	2,304
1963	9,048	1,384	1,634	474	12,813	2,294
1964	8,404	1,347	1,849	465	13,213	2,283
1965	7,586	1,242	2,201	576	14,063	2,422
1966	6,634	1,061	2,322	575	14,725	2,733
1967	5,767	982	2,247	622	15,233	3,280
1968	5,014	853	2,736	749	16,174	2,931
1969	4,526	780	2,658	702	13,244	2,818
1970	3,969	690	2,720	676	16,896	4,686
1971	3,510	673	2,709	668	17,541	4,779
1972	3,111	604	2,778	674	15,667	4,635
1973	3,133	589	2,966	673	14,782	5,004
1974	3,067	599	3,067	630	15,353	6,320
1975	3,187	583	3,050	689	15,856	5,260
1976	2,624	482	3,155	680	16,796	5,317
1977	2,288	447	3,079	688	17,185	5,491

Notation: B = production workers
W = non-production workers

Source: Ontario Metal Mining Statistics, op. cit.

APPENDIX TABLE 4

Compensation Paid per Employee for Total, Gold and Iron Ore, and "Other" Mining Activities in Ontario, 1961-1977

	Total Mining $	Gold and Iron Ore $	"Other" $
1961	4,791	4,089	5,323
1962	4,863	4,212	5,370
1963	4,879	4,305	5,362
1964	4,996	4,546	5,349
1965	5,217	4,743	5,547
1966	5,480	5,133	5,690
1967	6,358	5,364	7,115
1968	6,875	5,841	7,371
1969	6,949	6,161	7,377
1970	8,162	6,764	8,581
1971	9,472	7,099	9,008
1972	9,188	8,006	9,632
1973	9,706	8,889	10,044
1974	10,323	10,237	10,358
1975	12,488	12,012	12,671
1976	14,027	14,290	13,936
1977	15,191	15,958	14,942

Source: Ontario Metal Mining Statistics, op. cit, pp. 64, 66, 69 and 72.

APPENDIX TABLE 5

Distribution of Compensation Payments per Employee, Total Metals, Annually, 1961-1979

	Pay for Time Worked (Direct) (1)	Paid Time Off (2)	Other (3)	Employer Contributions: Payments Required By Law (4)	Employer Contributions: Benefits Plans (5)	Total Indirect (6)
1961	4,710	329	24	190	345	888
1962	5,174	412	24	217	378	1,031
1963	4,798	374	25	188	292	879
1964	4,382	330	20	165	340	855
1965	5,739	366	39	168	389	962
1966	5,416	354	37	227	327	945
1967	6,844	554	41	248	376	1,219
1968	6,985	581	39	249	432	1,301
1969	5,767	429	42	227	415	1,113
1970	8,116	683	51	297	712	1,743
1971	8,450	791	57	369	857	2,074
1972	9,155	988	81	404	1,065	2,538
1973	7,970	898	131	428	1,346	2,803
1974	10,366	1,324	113	625	1,466	3,528
1975	11,608	1,622	123	920	1,626	4,291
1976	13,724	1,748	152	1,325	2,270	5,495
1977	15,050	1,827	217	1,700	2,513	6,257
1978	13,940	1,603	235	1,421	2,356	5,615
1979	14,160	1,900	361	1,394	2,684	6,339
Rate of Growth per Annum						
1961-72	6.23	10.51	11.69	9.10	10.97	10.49
1972-75	8.23	17.96	14.94	31.56	15.62	19.13
1975-77	13.86	6.13	32.82	35.93	24.32	20.75
1977-79	-3.26	1.98	28.98	-10.43	3.35	0.65

Source: Ontario Metal Mining Statistics, pp. 154-5.

APPENDIX TABLE 6

Mining Study Gold and Iron
Distribution of Compensation Payments per Employee
Gold and Iron Ore, Annually, 1961-1979

	Pay for Time Worked (Direct)	Paid Time Off	Other	Employer Contributions: Payments Required By Law	Benefits Plans	Indirect
	(1)	(2)	(3)	(4)	(5)	(6)
1961	4,214	181	5	375	77	638
1962	4,043	190	6	363	99	658
1963	4,224	203	9	388	116	716
1964	4,373	205	10	384	123	722
1965	4,525	207	16	297	145	665
1966	5,069	222	27	587	138	974
1967	5,267	227	18	718	153	1,116
1968	5,185	267	5	759	173	1,377
1969	5,818	309	4	634	289	1 236
1970	6,109	358	7	566	332	1,263
1971	6.492	390	6	62	352	1,310
1972	7,725	460	93	511	526	1,590
1973	693	565	119	604	532	1,820
1974	9,582	534	259	897	477	2,167
1975	11,484	678	376	1,330	597	2.981
1976	13,529	923	473	1,645	796	3,837
1977	15,411	1,060	579	1,877	1,016	4,532
1978	19,378	1,063	403	1,694	969	4,129
1979	18,244	1,336	1,143	2,021	1,280	5,780
Annual Rates of Growth						
1961-72	5.88	9.07	30.44	3.08	19.36	8.89
1972-75	14.13	13.81	59.30	37.55	4.31	23.31
1975-77	15.84	25.04	24.09	18.80	30.45	23.30
1977-79	8.80	12.26	40.50	3.76	12.24	12.93

Source: Ontario Metal Mining Statistics, op. cit, pp. 156 and 157.

APPENDIX TABLE 7

<u>Distribution of Compensation Payments per Employee, "Other" Metals, Annually, 1961-1979</u>

	Pay for Time Worked (Direct) (1)	Paid Time Off (2)	Other (3)	Employer Contributions: Payments Required By Law (4)	Employer Contributions: Benefits Plans (5)	Indirect (6)
1961	4,766	345	26	171	373	915
1962	5,281	436	26	198	409	1,069
1963	4,839	391	26	165	310	892
1964	4,403	340	21	151	356	868
1965	5,812	375	40	160	404	979
1966	5,418	359	38	211	334	942
1967	6,899	566	42	229	384	1,221
1968	7,061	594	41	228	443	1,306
1969	5,755	435	43	205	421	1,104
1970	8,197	697	53	285	728	1,763
1971	8,535	809	60	361	878	2,108
1972	9,235	1,019	80	398	1,097	2,594
1973	8,067	920	132	411	1,397	2,868
1974	10,440	1,408	98	595	1,550	3,651
1975	11,621	1,720	96	877	1,734	4,427
1976	13,713	1,821	121	1,292	2,402	5,636
1977	15,007	1,892	186	1,683	2,642	6,402
1978	13,858	1,673	214	1,382	2,537	5,806
1979	14,356	1,970	260	1,312	2,861	6,403
<u>Annual Rate of Growth</u>						
1961-72	6.20	10.35	10.76	7.98	14.90	11.54
1972-75	7.91	19.02	6.27	30.08	16.42	19.45
1975-77	13.76	5.00	39.19	38.64	23.54	20.34
1977-79	-2.20	2.06	18.46	-13.20	4.13	---

Source: <u>Ontario Metal Mining Statistics</u>, <u>op</u>. <u>cit</u>, pp. 158 and 159.

APPENDIX TABLE 8

Payments Required by Law, By Category, Total Mines Surveyed 1961-1979

Year	Workman's Compensation (1)	Unemployment Insurance (2)	CPP (3)	Silicosis (4)	Other (5)	Total (6)
	Unadjusted cost per worker					
	(dollars)					
1961	126.64	44.57	-	13.94	-	185.15
1962	151.51	50.85	-	15.50	-	217.86
1963	125.17	46.94	-	14.91	-	187.02
1964	113.22	42.48	-	9.44	-	165.14
1965	119.28	45.15	-	2.98	-	167.41
1966	103.68	40.17	77.00	5.93	-	226.79
1967	122.46	40.45	75.82	9.20	-	247.91
1968	125.69	49.99	79.09	10.84	-	265.60
1969	111.10	44.96	64.90	9.38	-	230.34
1970	142.16	56.62	89.86	8.01	-	296.66
1971	197.99	64.79	97.60	8.27	-	368.65
1972	216.96	84.89	93.88	8.29	-	404.02
1973	235.73	90.54	92.46	10.49	0.01	429.22
1974	312.52	144.32	106.24	20.79	0.02	583.89
1975	530.67	158.16	120.18	47.27	0.02	856.30
1976	847.39	202.77	137.98	70.52	0.02	1,258.68
1977	1,175.47	205.11	159.40	93.32	0.03	1,633.33
1978	985.49	176.94	149.86	35.46	0.70	1,348.45
1979	914.17	170.55	150.24	34.13	13.65	1,281.74

Source: Ontario Metal Mining Statistics, Section 5, Labour Cost Survey.

APPENDIX TABLE 9

Adjusted Labour and Capital Factor Shares, Annually, 1961-77

Year	S_L (1)	S_K (2)
1961	.2639	.4373
1962	.2777	.4080
1963	.2615	.4239
1964	.2484	.4438
1965	.2410	.4171
1966	.2720	.3528
1967	.2362	.3922
1968	.2301	.3950
1969	.2266	.3653
1970	.2429	.3378
1971	.2878	.2465
1972	.2909	.3120
1973	.2448	.4160
1974	.2045	.4865
1975	.2717	.3534
1976	.2889	.3227
1977	.3168	.2703

Source: See text

Note: S_L = labour's factor share
S_K = capital's factor share.

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